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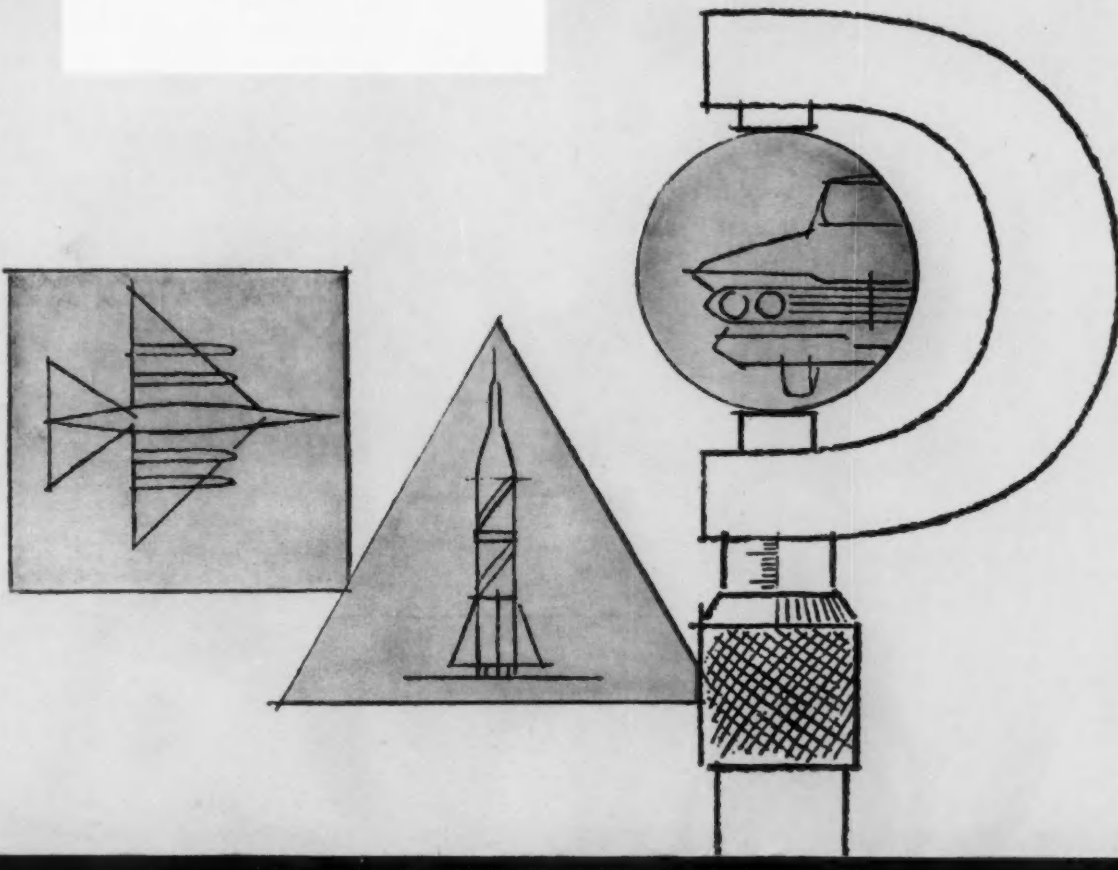
SAE JOURNAL



SAE JOURNAL

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Contents • April, 1961

INDEX of 1961 SAE Journal technical articles will appear in the December 1961 issue

To order papers on which articles are based, see p. 6.

Continued on page 2

Contents • April, 1961 • Continued

More on page 1

To order papers on which articles are based, see p. 6.

A complete index of all Journal technical articles, from January through December, will appear in the December issue. All Journal technical articles are indexed by Engineering Index, Inc. SAE Journal is available on microfilm from University Microfilms, Ann Arbor, Mich.

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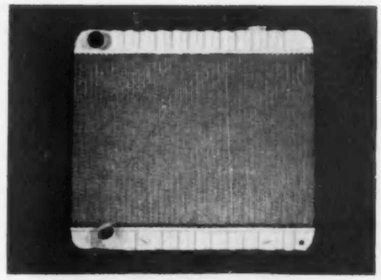

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To order the SAE papers digested here, circle the numbers in the "Readers Information Service" blank on p. 6 corresponding to the numbers appearing after the titles of the digests of the papers you want.

AEROSPACECRAFT

Economics of Supersonic Transport, S. M. HOROWITZ. Paper No. 239A. Report intends to acquaint engineer with methods of economic analysis using design of supersonic transport as example to show how market forces can be translated into profitable aircraft; problem is limited to early supersonic transport design characteristics of velocity, range, and seating capacity; selection of most profitable combination of these characteristics, and determination of size of profit.

Mass Transportation by High-Speed VTOL, H. V. BORST, J. M. MERGEN. Paper No. 266G. Requirements of local service market, limitations of helicopter and concept of using secondary propeller force to provide aircraft lift; VTOL development program of Curtiss Wright Corp., and design of Model 300 short-haul VTOL 4-engine transport having cruise speed of 300 to 400 mph, capacity of 50 passengers, range of 500 mi, pressurization, etc.; aircraft with four tilt propellers is of all metal semi-monocoque construction; safety, noise, wake velocity, performance and cost study.

Aerodynamic Design and Performance of Centrifugal and Mixed-Flow Compressors, F. DALLENBACH. Paper No. 268A. Test results of 12 compressors, comprising impellers consisting of backward curved, straight radial vanes and research mixed-flow impellers; compressors comprise AiResearch production models used in small gas turbines for bleed air and shaft power application; results show that, by following criteria with respect to impeller blade loading distribution, high overall-compressor stage efficiencies are obtainable.

Influence of Impeller and Diffuser Characteristics and Matching on Radial Compressor Performance, C. RODGERS. Paper No. 268B. Performance of gas turbine compressor is function of impeller and diffuser characteristics, and their relative matching and interaction; characteristics for radial compressor, synthesized from equivalent linear 2-dimensional cascade data, and momentum equation, are combined to derive overall compressor performance; trends in matching between impeller and radial diffuser and use of techniques at Solar Aircraft Co.

Transonic Flow Problems in Centrifugal Compressors, A. F. STAHLER. Paper No. 268C. Qualitative analyses of flow problems encountered while operating centrifugal compressor impellers, used with gas turbines, with transonic inlet and discharge Mach numbers; modifications used to reduce adverse effects of transonic flow phenomena, and comparative results of testing compressors with and without these modifications are presented.

Combined Transonic Axial and Centrifugal Stage Compressor, C. J RAHNKE, R. H. CARMODY. Paper No. 268D. Characteristics of gas turbine compressors ranging from multi-stage axial flow to multistage centrifugal designs; details of compressor arrangement designed by Continental Aviation by combining transonic axial and centrifugal stage; by utilizing h-p ratio transonic stages, overall-pressure ratios of 6.0:1 or 7.0:1 can be achieved with one or two transonic stages and centrifugal stage; problems unique to matching transonic axial to centrifugal stage.

Ground-Effect Machine Applications in Mixed Terrains, M. M. CUTLER, A. F. KOSSAR. Paper No. 270C. Capability of machines to travel over land, water, mud, ice, snow, sand, suggests applications as high speed amphibian and off-road land vehicles; low foot print pressure, usually 0.1 to 0.3 psi, suggests military application for mine detection; factors affecting operation; materials and hardware used; design and fabrication problems of Curtiss-Wright GEM prototype.

continued on page 6

Briefs of SAE PAPERS

continued from page 5

Some Effects of Runway Slush and Water on Operation of Airplanes, with Particular Reference to Jet Transports, W. B. HORNE, U. T. JOYNER. Paper No. 275A. Study of braking coefficient of friction of tire on runway and tire rolling resistance was made at NASA Landing Loads Track, to assess distance required for takeoff or landing; differences found in coefficient development by different tire tread patterns, and rolling resistance of tire in terms of forward speed and slush or water depth; results are used in calculations to yield incremental takeoff and landing distances.

Clearing Snow Off Runways at High Speed, D. B. REES. Paper No. 275B. 4-yr program carried out by Royal Canadian Air Force and manufacturer to design runway sweeper traveling at 25-mph forward speeds; British made broom consists of thin steel bristles, grommetted in clusters and sealed on to core by rubber clasps; 6 × 6-in. single castor wheels are covered with rubber; snow blower discharges 30 tpm of snow, is powered by rear mounted 335-hp, 6-cyl turbocharged Cummins diesel engine; specifications and test runs.

Determining and Reporting Braking Qualities of Icy or Snow-Covered Runways, B. HOLMER, G. ANTVIK. Paper No. 275C. Techniques at Scandinavian Airlines System include: meteorological observations, skidding truck to calculate braking action from time and distance; recording deceleration with accelerometer; special trailer giving continuous registration of braking efficiency; results show that either method can be used; advantages of trailer method; transmission of data to pilots.

Nozzles for Liquid Rockets, R. C. KOPITUK. Paper No. 280A. Case history on development of X-15 rocket combustion chamber by Thiokol Chem. Corp.; spaghetti or channel construction chosen consists of thin walled formed metal tubes placed side by side; area subjected to most severe operating conditions is nozzle; selection of materials and fabrication methods; development of manual inert gas arc welding techniques and modifications to gas side surface of Type 347 stainless steel; final set of materials include zirconium dioxide, Nichrome undercoat, Type 347 tubing, CM 62 or NX-1 braze alloy, metal filled epoxy resin stabilizer and 17-7PH (CH) wire wrap.

Evolution of Cast Internally Cooled Gas Turbine Airfoil, H. L. McCORMICK. Paper No. 280B. Step by step description of lost wax investment method; to overcome its limitations, use of preformed cores was investigated at Allison Div. of General Motors; preformed soluble ceramic cores molded from American Lava Corp. Alsimag 145 ceramic material provide monolithic cast airfoils having hollow internal geometry which permits maximum heat transfer for air cooling; metallurgical investigation has shown castings to be sound; inspection methods for close quality control.

Cooling for Hypersonic Aircraft Structures, H. MUND. Paper No. 280C. Concept of cooled and insulated aluminum load-bearing structure evolved at Bell Aerosystem Co. to provide protection to equipment and personnel within vehicle; use of double wall comprising riveted aluminum inner wall through which coolant is circulated, outer wall of small high temperature shields which connect to inner wall, and layer of insulation in foil containers between inner and outer walls; cooling system proposed using water heat sink; evaluation of method of coolant passage fabrication.

Passenger Handling for Jet Age Airport Mobile Lounge, J. M. MARTIN. Paper No. 283A. Concept and design of mobile departure lounge by Chrysler Corp. to move passengers from terminal building to aircraft and back; vehicle operates in either direction with no penalty in maneuverability, driver visibility, or operating economy and is designed for one-man operation; steps undertaken to establish requirements for vehicle and manner in which major characteristics were approached; driver location, floor plan, drive train,

continued on page 127

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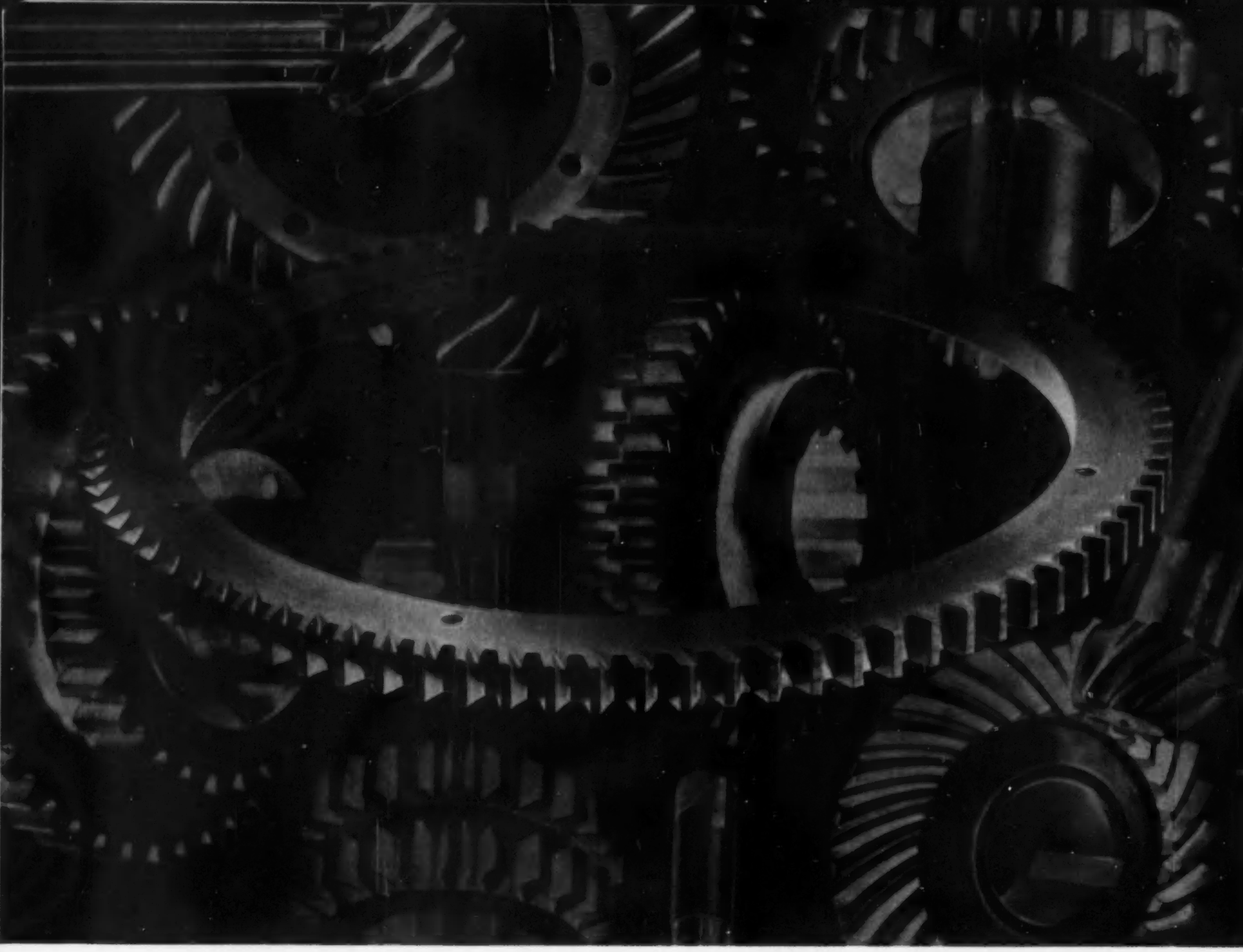

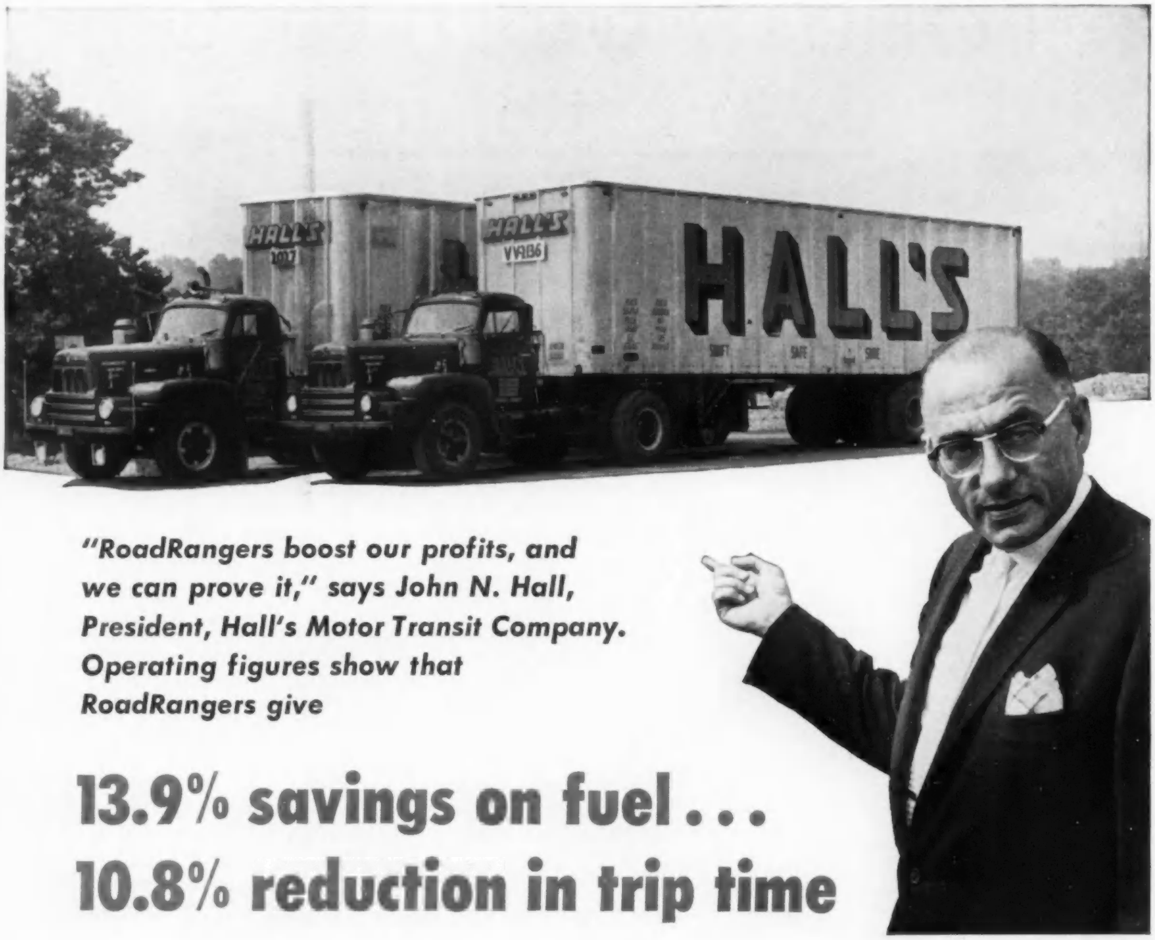

"RoadRangers boost our profits, and we can prove it," says John N. Hall, President, Hall's Motor Transit Company. Operating figures show that RoadRangers give

13.9% savings on fuel . . .
10.8% reduction in trip time

Hall's Motor Transit Company, Sunbury, Pa., expects to gross over \$17-million in 1961. To achieve this goal, Hall's over-the-road fleet will log about 15 million miles and haul more than a billion pounds of freight.

"With an operation this size," says President John N. Hall, "we need to keep detailed figures on the performance and reliability of every unit in our fleet. Comparative studies prove that Fuller RoadRangers have been responsible, in large measure, for our trouble-free operation, substantial fuel savings and overall efficiency."

Nearly 93% of Hall's road tractors are Internationals equipped with Fuller RoadRangers. 286 of the units are R-200s with R-46 8-speed RoadRangers and 23 are RD-225 Diesels with R-96 10-speed RoadRangers.

Hall's RoadRanger-geared tractors average 13.9% better fuel mileage than rigs using the same engine but with transmissions of another manufacturer. Fuller-geared trucks cut trip time an average of 10.8%.

Maintenance figures have been impressive, too. Says Mr. Hall, "Road failures have been reduced to an absolute minimum, and we have several RoadRanger-equipped tractors with over 125,000 miles that haven't cost us a cent in unscheduled maintenance. The RoadRanger is truly an outstanding transmission."

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What synthetic sealing materials should I use—and when

Environmental conditions generally dictate the type of synthetic rubber for a specific oil sealing application.

Where temperature, shaft speed, runout, eccentricity, and lubricant type are "normal", standard Buna N synthetic rubber compounds are satisfactory. If, however, the application is "dry running", a compound must be selected that will operate satisfactorily with a very small amount of lubricant. If the application involves excessive abrasion, highly "loaded" compound stocks should be provided. At temperatures over 250° F polyacrylics or silicone compounds are indicated; if high temperature is accompanied by a solvent base or additive lubricant, polyacrylics are definitely preferred.

Thus many variables govern successful oil sealing. The chart below gives more data; for complete information from the world's foremost oil seal laboratories, call your National Seal engineer. He's in the Yellow Pages, under Oil Seals or O-Rings.

SYNTHETIC RUBBER COMPOUNDS / **RECOMMENDED APPLICATIONS**

Comp. No.	Base Polymer	Min/Max Operating Temperature	Life Index	Price Index	Automatic Transmissions	Pinions	Axle Seals	Engine Seals	Misc. Applications
B-63	Buna N	—40°F/225°F	100	100				Excellent for small gas engines.	Excellent for small non-spring loaded seals.
B-86	Buna N	—30°F/225°F	100	100		Satisfactory for medium temperature applications.	Truck and automotive rear axles. General use.	Satisfactory as general purpose material where temperature permits.	General purpose Buna N applications.
B-94	Buna N	—60°F/250°F	100	100					Excellent against aromatics and some military aircraft oils, fuels.
B-95	Buna N	—30°F/225°F	100	100					Good dry running compounds for applications requiring high durometer stock.
C-6	Buna N	—30°F/225°F	100	100			Excellent for semi-rough axles. Has good wear qualities.		Good for pressure seals due to high durometer and clean trimming.
L-28	Acrylon BA-12	—30°F/300°F	400	125	Good for temperature range indicated.	Satisfactory in single lip construction.	Sealed bearing high temperature applications.	Satisfactory for automotive use. High temperatures.	Satisfactory for high temperature general applications. Can be used with EP or GL-4 oils.
L-34	Hycar PA-21	0°F/300°F	400	115	Good for temperature range indicated.	Dual lip limited contact for high temperatures.	Sealed bearing high temperature applications.	Satisfactory for automotive use. High temperatures.	Satisfactory for high temperature general single or dual lips. Ok with EP or GL-4 oils.
S-48	Silicone*	—80°F/400°F	1500	150	Excellent high and low temperature life.	Silicone Compounds Not Recommended With EP Lubricants at high temperatures.		Excellent for general engine use. Suggested for premium gasoline and Diesel engines.	Excellent wide range material. Avoid use in EP and GL-4 oils.
S-49	Silicone*	—80°F/300°F	600	130	Good at high and low temperatures.			Very good for general engine use; premium gasoline and Diesel engines.	Very good wide range material. Avoid use in EP and GL-4 oils.

*Silicones require special stabilization for satisfactory use in aromatic oils at high temperatures.

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NEW SUPER-TOUGH ORE HAULER USES

N-A-XTRA

HIGH-STRENGTH STEEL

TO CUT DEAD WEIGHT AND STRETCH PAYLOAD CAPACITY

This Lectra Haul M-55, made by Unit Rig and Equipment Co. of Tulsa, is now working in the open pit iron mines in Minnesota's Mesabi range. In bone-freezing —40° weather, it can stand up to the shuddering shock of 55 tons of drop-loaded iron ore, climb a 6% grade at 8.6 mph then dump those 55 tons in a crashing, grinding 18 seconds. The quarry body that takes this loading impact and dumping abrasion in sub-zero temperatures is made of N-A-XTRA high-strength steel, with X-A-R Abrasion Resistant Steel for extra hardness and toughness in wear areas. N-A-XTRA also forms the structural members of the complete unit.

Why N-A-XTRA? Because, pound for pound, it's nearly three times stronger than ordinary steel. That means it's strong enough to absorb severe punishment without constant maintenance, and light enough to handle the highest possible payload. In fact, the Lectra Haul payload is almost as much as the net vehicle weight itself.

N-A-XTRA and X-A-R are doing the job where only the strongest steels will do. Easily formed and welded, they are making products stronger, lighter, longer lasting. N-A-XTRA fully quenched and tempered steel is available in four levels of minimum yield strengths, from 80,000 to 110,000 psi. X-A-R steels are supplied in hardnesses from 360 to 400 BHN (or, by agreement, in a range between 265 and 500 Brinell). For full technical information, write Great Lakes Steel Corporation, Product Development, Dept. SAE-1, P.O. Box 7310, Detroit 2, Michigan.

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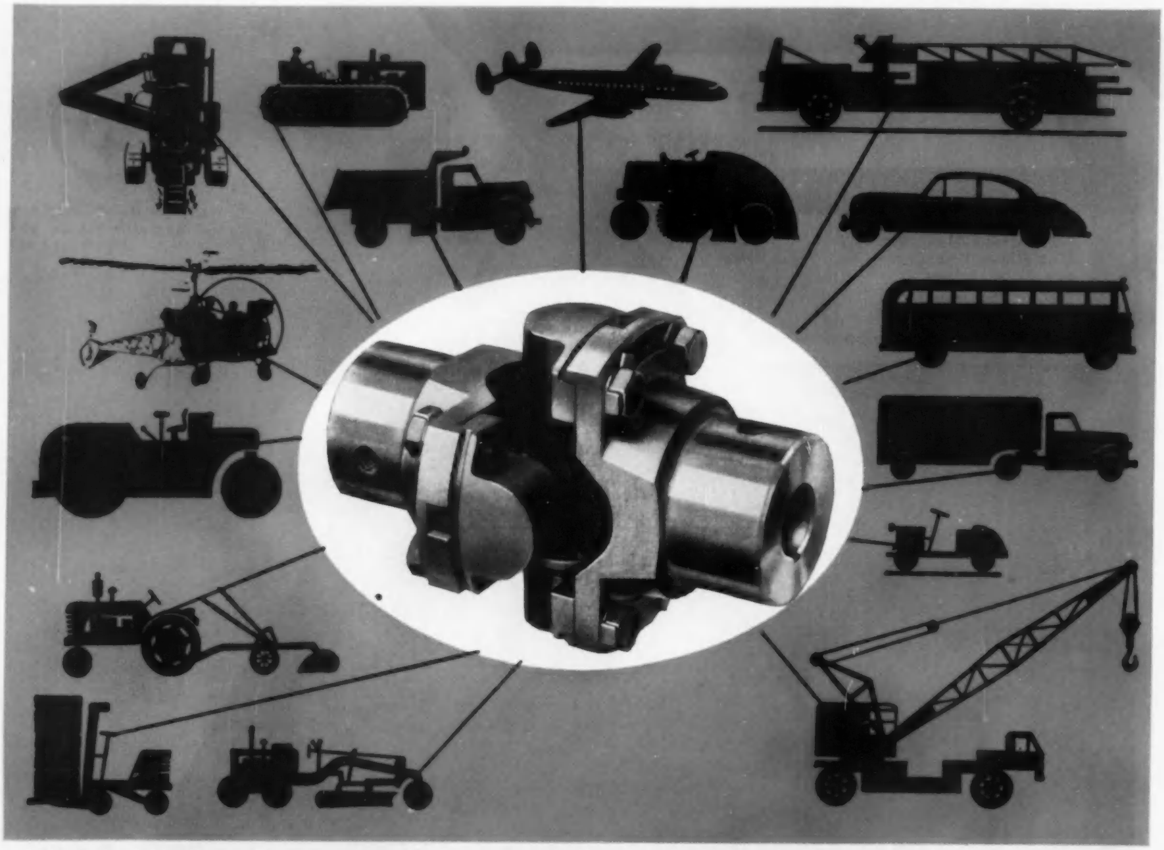
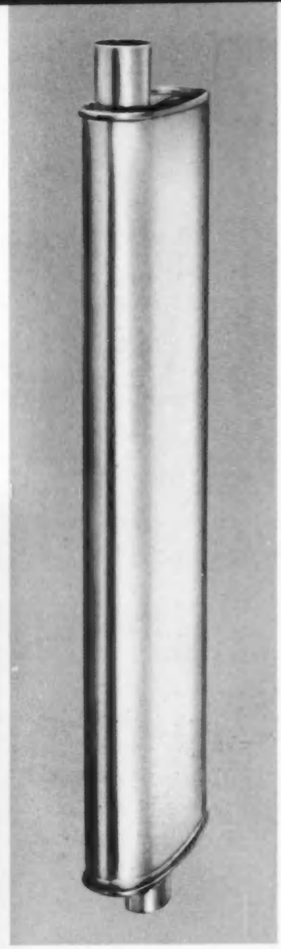
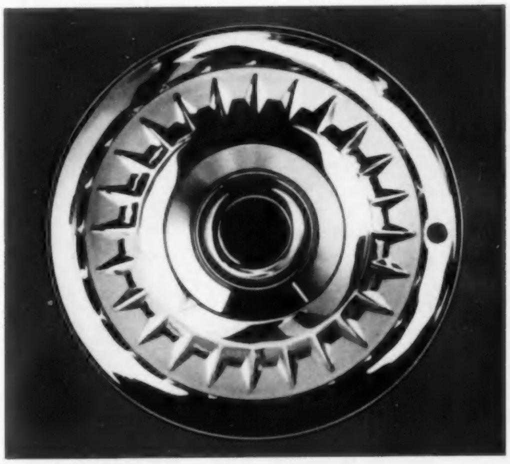
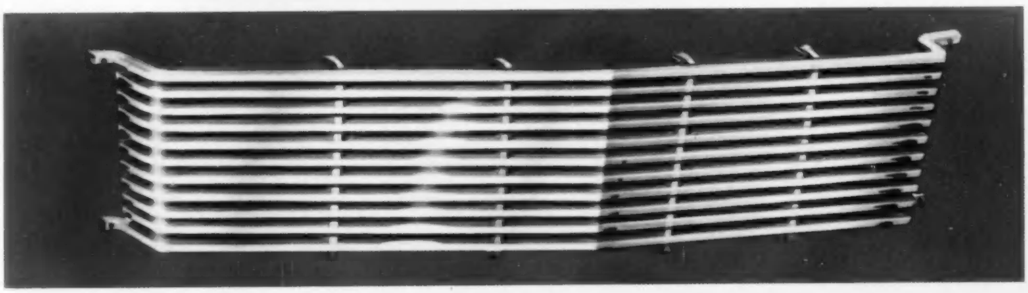
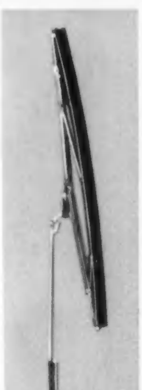


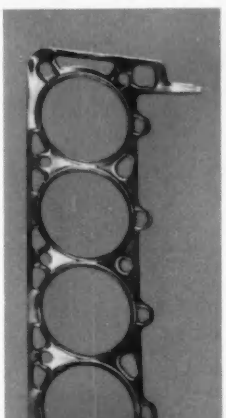
Automotive Horizons and Allegheny Stainless...

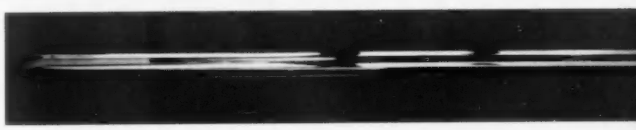




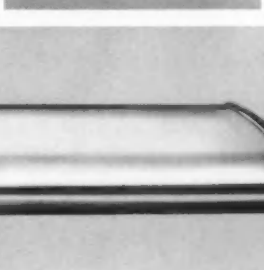








Twenty-five years ago, six special '36 Ford V-8's were made of Allegheny Metal, today's Allegheny Stainless. They proved that nothing lasts like Allegheny Stainless. On the car shown above, tires wore out, shocks had to be replaced, yet the stainless was like new. Gears and transmission wore out. Mileage passed 250,000. Still the stainless was like new. Now a veteran of four engines and 400,000 miles, the Allegheny Stainless is just as good as it was when it left the factory—always stainless, always like new.



This T-Bird is all Allegheny Stainless. The Budd Company, fabricators of Thunderbird bodies, made the parts on its regular production dies from Allegheny Ludlum stainless steel taken from a regular production run. Ford completed the car and rolled it from the regular assembly line for delivery to Allegheny Ludlum. Body work is Type 302 stainless with a special satin finish; muffler, bumpers are 302. All trim is Type 430, mirror finish.

This Stainless 'Bird won't lose its plumage

Twenty-five years from now, this 1960 stainless steel Thunderbird will still look showroom new. Time won't dull its luster any more than it has the special 1936 Ford V-8—also made from Allegheny Stainless.

These cars, built 24 years apart, were made for Allegheny Ludlum as practical demonstrators of the long-lasting good looks of Allegheny Stainless, its corrosion resistance, its strength, and its ease of fabrication and joining.

A-L will display the new car—along with its new-looking older sister—at auto shows, in fairs, and exhibits to stimulate consumer interest in the lasting value of the stainless now being used so effectively on American automobiles.

No other material can keep pace with stainless steel. When you need beauty and practicality . . . long life . . . unexcelled engineering performance . . . you can rely on Allegheny Stainless, by the leading stainless supplier to the automotive industry.

For even better cars tomorrow, Allegheny Ludlum's research is constantly developing new stainless steels and new uses for existing stainless steels.

Even Stainless pops up with problems...

As you would expect, the growth and development of even stainless steel automotive applications have not been without some dark moments. With Allegheny Ludlum's considerable background in the automotive applications, and even greater experience with stainless steel in a demanding variety of industrial environments, it came as a distinctly unpleasant surprise to learn that certain automotive trim parts of stainless were not standing up. Neither were other metals, but stainless must stand up.

BRIGHT ANNEAL FINISH

Isolated reports began to filter in from various locations throughout the country complaining of a frosty white etch appearing on Type 430 trim and molding components. Allegheny Ludlum's examination of the problem revealed that this condition was due to increasing use of road salt for snow removal. Other factors were processing changes made at the mill to meet the fabricators' demands for brighter strip finishes to reduce buffing costs.

Extensive research suggested that this condition was probably due to the final pickling operation given bright automotive strip. In processing, the strip was annealed conventionally which formed a thin oxide layer on the strip. Pickling was necessary to remove that oxidation. But heavy pickling tended to produce a duller finish. The problem was to eliminate or minimize the pickling that was needed to remove the oxide layer.

The automakers spelled out this problem: In addition to developing a finish that would resist this corrosive road condition, come up with a finish that was even brighter than before. Allegheny Ludlum analyzed its experience with smaller equipment where stainless steel was annealed in a vacuum or an inert atmosphere. The surface oxide was avoided and, therefore, so was the final pickling treatment. Result: better corrosion resistance than obtained in the past and a brighter finish.

The solution involves annealing stainless on a continuous, tonnage basis in a pure, dry hydrogen atmos-

...and here's how A-L solved them

phere which permits no oxidation or scaling, and keeps the surface clean and bright. A new Allegheny Ludlum furnace—the largest of its kind ever built in this country—went into full production on November 1, 1960, giving Allegheny Ludlum the tonnage capacity to service the automotive industry with Bright Annealed Allegheny Stainless Strip in all automotive stainless types in the brightest, most corrosion resistant state.

NEW—SUPER CORROSION RESISTANT A-L 433

Another problem faced recently was that of pitting and crevice corrosion on trim in certain, specific areas of the United States. After much investigation by the automotive companies and the stainless producers, it was believed that it was due to increased use, in combination, of deicing materials—salt, calcium chloride, slag, cinders—during winter in some sections of the country.

After extensive research in A-L's laboratories, a new steel to combat these conditions was developed. Tentatively called A-L 433 and patent applied for, it is an improved Type 430 alloy with the greatest corrosion resistance of any of the straight chrome stainless steels. Molybdenum is added to improve corrosion resistance against general pitting and copper is alloyed to enhance the moly in combatting crevice corrosion.

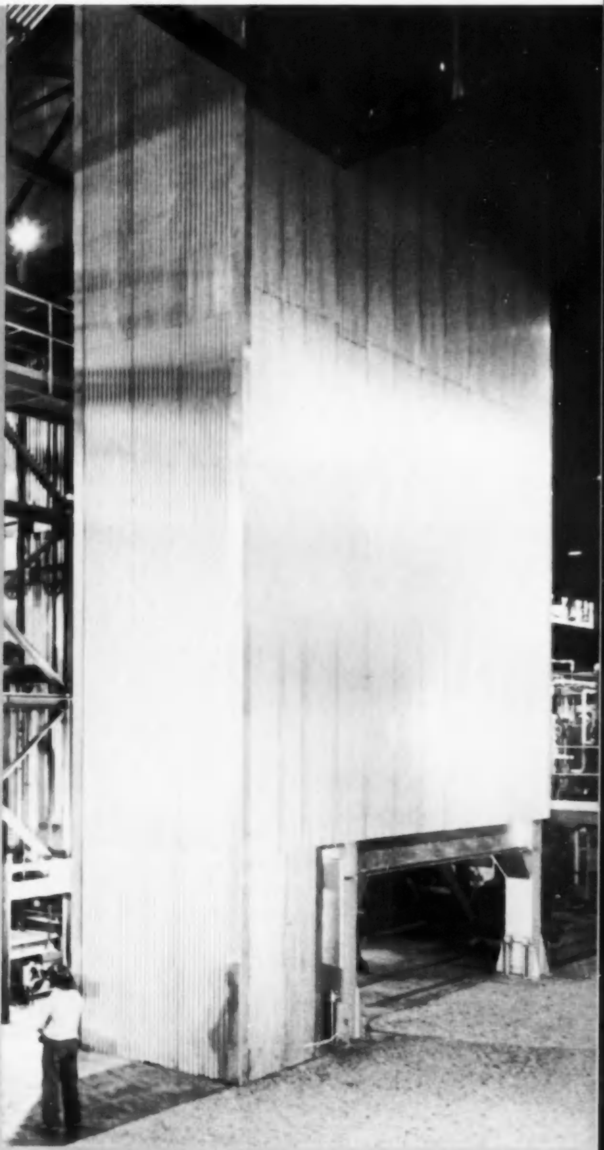
Available now, and at no premium in price over standard Type 430, A-L 433 should end the isolated complaints of pitting and crevice or joint corrosion, which has been called "red or back rust" in automotive slang.

MINIMUM ROPING TYPE 430

Another vexing problem reported, even though it was by no means universal, was roping. Some of the fabricators were running into this phenomenon which showed up as a lightly furrowed, wrinkled appearance, marring the surface of the finished part after severe stretching operations had been performed.

Heavy buffing, resulting in unusual costs, was required to eliminate these lines. Occasionally, it meant rejections. Considerable investigation and research has resulted in a special stainless steel strip with low roping characteristics. A combination of alloying and processing resulted in uniform ductility across the strip. A-L Type 430, low rope quality, is already in use in these applications.

And so, one by one, as unusual design, fabricating, and service conditions dictated, the problems of stainless in automotive service have been met head on and dealt with by Allegheny Ludlum in cooperation with the nation's leading automakers and fabricators. With its research and service teams, with its extensive production facilities, A-L expects to lead the way to the increased use of stainless steel in the automotive designs of the future.



Allegheny Bright Annealed Stainless Strip is produced in this special continuous annealing furnace, on line at Allegheny Ludlum since November 1, 1960. Bright annealed strip results in a more corrosion resistant and brighter finish.

STAINLESS...a growing force in today's automotive design

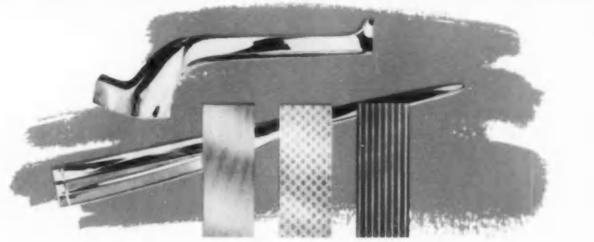
The continued improvement in stainless steels and the increased demand of today's motorists for attractively styled automobiles that stay attractive have combined to throw open the door to more and more stainless automotive applications. And longer warranties are pushing the trend to stainless. Here are some of the places you're most likely to find Allegheny Stainless on cars today... or maybe tomorrow.

Mufflers and Tailpipes

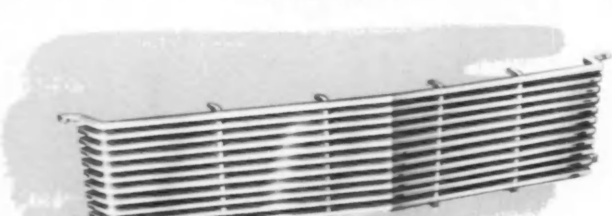
It's long been admitted by automotive people that a car shouldn't have one of its components operating in a hot, highly-corrosive environment without real corrosion resistance built into that part. But it's been a cost problem. Allegheny Ludlum's answer to the muffler problem is MF-1, a special, economical, ferritic stainless steel with good formability and corrosion resistance. Mufflers made from MF-1 have corrosion resistance built in. The stainless is solid. There will be mufflers made entirely from MF-1; others with MF-1 in the corrosion-susceptible internal wraps and baffles only. In either case, this corrosion resistance won't chip, peel, or burn off.

Trim

Nothing enhances the beautiful lines of an automobile like sparkling brightwork, and nothing is a bigger chore to care for if it begins to spot and pit, rust or peel. With Allegheny Stainless trim, the original beauty is a beauty forever, stainless clear through and as corrosion resistant in its old age as the day it came off the line. Highly formable, gleaming bright, protective and dent resistant...stainless steel.



Grilles



Nothing establishes the appearance of a car as much as the "expression on its face"...its front end-grille design. And nothing has more to contribute to the beauty, prestige, and crisp styling of the grille design than stainless steel. Allegheny Stainless in bar form, tubing, strip or patterned sheet lends itself to economical fabrication techniques...roll forming, expanded metal, spot welding...all important in any fabrication with as much resultant waste as present grille forming techniques. Automotive engineers, using some of these newer processes, are re-evaluating stainless.

Hubcaps and Wheel Covers

Wheel covers and hubcaps demand a variety of metal characteristics and some are almost mutually incompatible...springiness, formability, dent resistance, brightness, corrosion resistance, scratch resistance, dimensional stability, stiffness...and more. Only one metal can come close to meeting all these requirements...stainless steel.

STAINLESS...both on and over the automotive horizon

More and more stainless steel will appear on the cars of tomorrow. Everything points to it . . . today's conditions require it, so will tomorrow's. There's a definite trend to longer warranty periods. Competition will probably cause these warranties to be extended, and extended yet again. Parts simply must last longer to make these warranties possible.

There's also a trend toward less owner-maintenance, such as sealed lubrication systems, sealed engine coolant and automatic air conditioning systems, self-adjusting brakes, and the like. Design features such as these will continue. Again, competition will probably force the extension of such systems, and their inevitable elaboration.

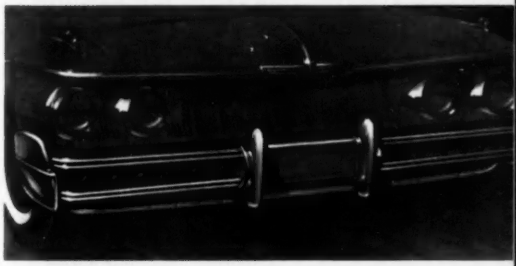
Both trends lead to increased use of Allegheny Stainless. When parts just have to stand up in warranty, the call is for stainless. And when less owner-maintenance develops, the corrosion resistance and foolproof characteristics of stainless begin to pay off. Such hidden applications as fuel tanks, floor pans, surge tanks, radiator systems, etc., are already receiving a good, hard look from engineers as future stainless applications.

Other requirements are advanced by design problems and improvements in automotive interiors. Gleaming, durable stainless steel makes a sales feature of the constant, close-up scrutiny of even the most discriminating auto passenger. It stands up under constant handling, scuffing and lack of polishing and provides the modern automotive interior with the ornamental brilliance that is uniquely stainless.

Characteristic of stainless, as well, is its remarkable ability to withstand elevated temperatures for long periods of time, and to resist corrosive environments under such conditions. As early developmental work has shown, this admirably fits it for service on the numerous anti-smog devices now vying for official recognition. With service temperatures as high as 1800 F, with lead oxide, sulfur, catalysts, and other chemical corrosion a factor, no other material can be actively considered aside from a stainless, heat-resisting steel.

These are just a few thoughts on how Allegheny Stainless and the automotive designers will be working for motoring enjoyment . . . tomorrow or the next day.

Bumpers



Possibly the most exciting design possibilities involve the front and rear of the modern automobile and the need for bumpers. Designers are faced with the task of integrating a massive section of metal into an overall design concept. Stainless steel can play a very great part in this effort, from both the esthetic and structural standpoints.

One interesting bumper technique is the fabricated bar bumper of stainless steel. Solid stainless bars offer an unmatched combination of beauty and strength, are easily formed, and may be worked into a variety of front-end designs featuring floating grilles and fabricated bumper guards. Stainless bars are repairable, by straightening, welding, buffing . . . all relatively simple operations.

Or, the protection and beauty of stainless steel may be obtained in a bumper with a metallurgically-bonded stainless cladding over the baser, underlying metal. Cladding offers the same exterior corrosion resistance and durable beauty as solid stainless designs. It won't scrape, peel, or rust. And, for maximum impact strength, and equal protection with lighter cross sections, some of the high strength stainless grades offer most interesting avenues for exploration.

Interiors

The *hidden* Value of Stainless in Automotive Design...

Ask a housewife about this strong and handsome metal ...about its useful life, its strength, its corrosion resistance. She'll be able to tell you...she lives with it daily and sees it everywhere. She knows its beauty and prestige-building appeal, its dollar-value economy.

But aside from these obvious advantages, stainless steel has hidden values for those who really know it well, an added desirability based on reasons both functional and esthetic...practical and personal.

IN DESIGN ...to designers, stainless steel has a highly utilitarian character. Designers feel better about working with its honest nobility. They prefer its reliability, its mathematical predictability, its strength, the look and feel of it, and its uniquely masculine character. It's a designer's metal.

IN STYLING ...to stylists, the rich luster and high prestige of stainless steel provide an irresistible creative challenge. They are intrigued by the limitless possibilities offered by its variety of textured surfaces and finishes, its ease of forming, bending, shaping. It's an expressive metal... a stylist's metal.

IN MARKETING

...salesmen and marketing men know the value of stainless in automotive design. They know a customer's reaction to it. They know the universal appeal of stainless, the built-in customer acceptance based on its unqualified success in kitchen and other home appliances, in sporting goods, jewelry, and cutlery. It helps sell. It's a salesman's metal...a marketing metal.

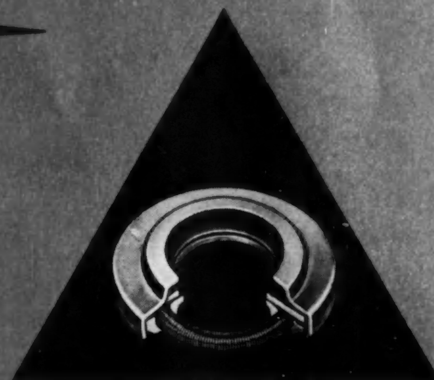
ALLEGHENY LUDLUM STEEL CORPORATION

General Headquarters: Oliver Building, Pittsburgh 22, Pa.

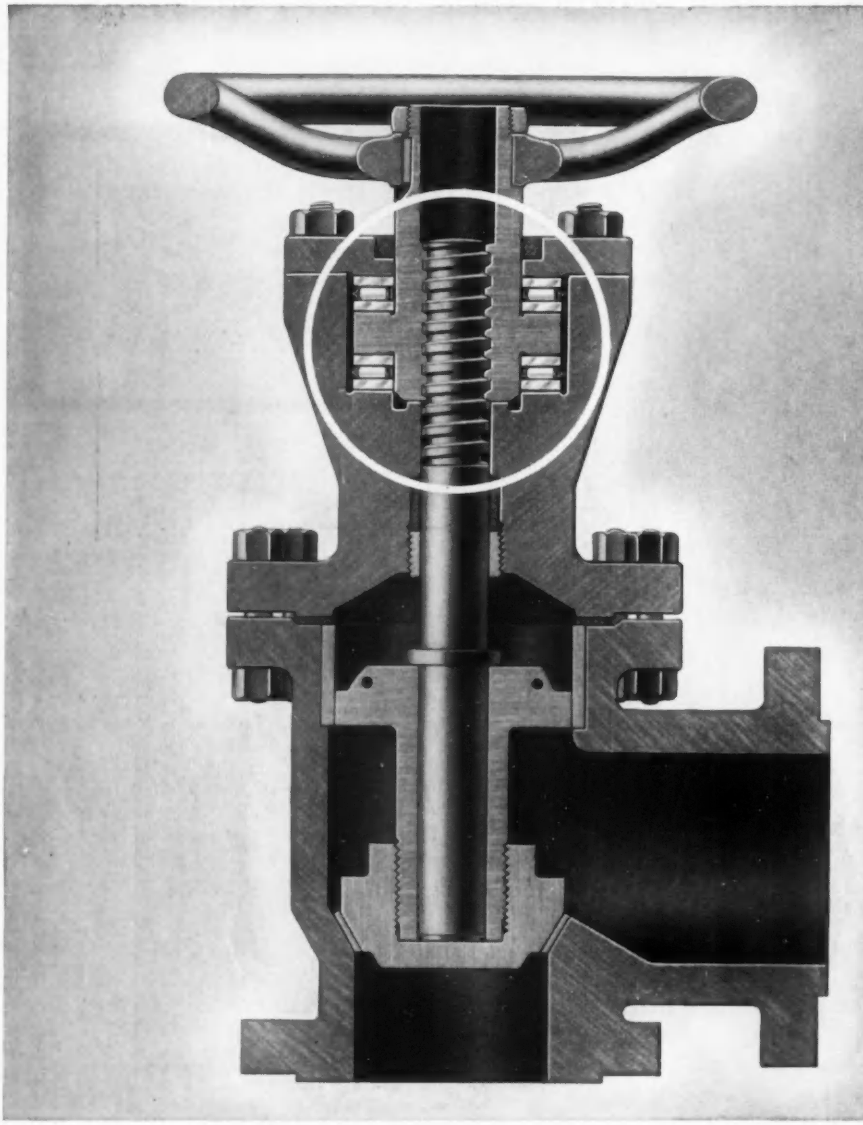
EVERY FORM OF STAINLESS ... EVERY HELP IN USING IT

2909-A

Litho in U.S.A.




"Gee! Harriet . . . howd'ja know it was a Mather Suspension?"
"It's easy . . . it rides so sm-o-o-o-o-th!"
WHAT'S GOING ON DOWN UNDER



Torrington Needle Thrust Bearing

Torrington Thrust Race

Compact valve design, easier operation with Torrington Needle Thrust Bearings

High thrust capacity, thin cross section and low unit cost have made Torrington Needle Thrust Bearings a natural choice for top valve performance. With Torrington Needle Thrust Bearings, only a fraction of the normal closing effort is needed. This puts less strain on the valve... means smoother, more reliable operation. Lifetime pregreasing insures peak efficiency over years of extra service life.

Torrington Needle Thrust Bearings are exceptionally compact. They provide an assembled height far less than any other type of thrust bearing. They may be run directly on adjacent hardened and ground surfaces, or, as shown above, on standard Torrington thrust races.

If you make gate valves, globe valves, angle valves—in fact, any valve closed on a threaded stem—you'll find it pays to investigate the top efficiency of Torrington Needle Thrust Bearings. Call or write Torrington—maker of every basic type of anti-friction bearing.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

SAE
JOURNAL

For Sake of Argument

Behavior . . .

DRIVER-BEHAVIOR studies are focusing some facts which help to explain (to us at any rate) why people act the way they do in any human relationship.

Take, for instance, five of the "general psychological principles relating to man's ability to observe," which researchers regard as axiomatic:

- **"Man can make continuous observations in each of the sensory modalities simultaneously."**

  So, is it any wonder it takes him a couple of days to sort out a clean-cut response when the boss calls him in and says: "We've decided to transfer you back from technical sales to research."

- **"Within any of his sensory modalities (we have at least 11 senses according to psychologists), he must choose to divide the time of continuous observations between all the continuous events that occur."**

  While he's trying to figure out what this means in dollars, the boss's telephone rings, the vice-president comes in through a side door, and the boss's secretary knocks over a vase of flowers.

- **"Any one or more of the senses may be unrespsonsive."**

  He doesn't hear too well, so he isn't bothered by the telephone, but is startled to see the vice-president.

- **"Attention may be focused on only one discrete event at a time."**

  Shall he pay no attention to the vice-president and help the secretary to clean up the flower mess . . . or vice versa.

- **"There is finite limitation (although it may vary) on the number of discrete events that can be observed at a given time."**

  He didn't even notice the boss's golf clubs standing near the door. So how could he know this wasn't the time to start a real discussion?

All flippancy aside, we do find stimulation to much serious thought about human behavior in general from the driver-behavior research reported recently to SAE by Ford's Fletcher N. Platt.

Norman G. Shidle

chips

from SAE meetings, members, and committees

AMBIENT SPACE PRESSURE approaches a perfect vacuum, but the dynamic pressure on a space vehicle may be considerably greater than the local static pressure. Depending upon the particular missile configuration, at an approximate speed of 18,000 mph, the dynamic pressure at 1,000,000 ft altitude corresponds to the static pressure at 500,000 ft.

INBOUND AND OUTBOUND shipping costs for components of a Plymouth car total 3¢ per lb. (Averages for other Chrysler Corp. lines vary somewhat depending on location of assembly plants, dealers and other similar factors.)

ALTERNATOR BRUSHES on a well designed unit are neither expensive nor troublesome. The current carried by the brushes is low and brush wear is mostly mechanical, resulting in brush life that is far superior to the best obtained on D.C. generators.

SUPPOSE you are a car engineer, trying to decide whether to use a malleable iron or aluminum steering gear housing in a new design. The iron housing weighs 14 lb more than the aluminum one, but its piece cost is $1.10 less.

However, if the weight-cost factors are used to dollarize the compounding effect of the 14 lb weight increase, the net cost of the iron version to the overall vehicle would be a $1 penalty instead of the $1.10 saving. . . . . This would certainly reverse the decision which would otherwise be made if the total cost of weight were not considered . . . . explains Chrysler's S. L. Terry.

BY 1980, if present trends continue, more than half of the American population will be living in cities that stretch across the country in great, contiguous metropolitan "regions" of a chaotic ugliness that will make the 1960 model look charmingly quaint by comparison. . . . So says Charles Blessing of Detroit City Planning Commission. He adds:

"Our 180 million people in 60 million housing units will, by 1980, have been increased to 240 million . . . with virtually all of the 60 mil-

"LADY BE GOOD", the recently found B-24 aircraft that lay in the North African Libyan Desert for 17 years, has performed one more mission. To further advance space age technology, the hydraulic components of the plane were removed and studied to determine the effects of exposure in the brutal desert environment. The object of these tests was to correlate findings to what might be expected to happen to similar space ship mechanisms, when they remain in the quiescent state on long interplanetary journeys.

Despite the long exposure, many of the components were found to operate as well as a new unit. For example, the engine driven piston pump met new unit delivery requirements, but had a shaft seal leak. For the most part, internal metal parts were found to be bright and shiny, although some units contained sand intermingled with the oil. Seals and gaskets remained soft and pliable under conditions where the temperature sometimes reaches 120 F and goes down to 26 F, and humidity ranges from 5 to 36%.

chips

from SAE meetings, members, and committees

lion increase going into our already-congested urban areas. This will be equivalent to 120 new cities of 50,000 persons each."

USE OF ALUMINUM in automobiles has more than tripled in 10 years — increasing from 125 million pounds in 1950 to 435 million pounds in 1960.

SNOW REMOVAL is big business for big equipment. At the 320-acre Montreal International Airport, for example, a 1-in. snowfall on the paved area necessitates removal of 13,000 tons of snow, 4659 tons from runways and taxiways alone. With an average annual snowfall of 80 in., every winter 1,040,000 tons of snow must be handled, picked up, and thrown at least 100 ft, with a lot loaded and hauled away.

THE AVERAGE AIRLINE PASSENGER walks about 650 ft from his parked car to the ticketing counter, and then about 950 ft from the counter to his airplane. These walks add up to about five times the length of a football field.

FUEL ECONOMY OF TURBINE-POWERED CARS is greatly affected by regenerator efficiency. For example, at 40 mph, a 100-hp gas turbine might give 20 mpg with a regenerator of 90% efficiency. This would drop to 12½ mpg with a regenerator of only 70% efficiency. With no regenerator, fuel economy would be only about 5 mpg.

FLIGHT DELAYS due to trouble with flight instruments have affected about 1% of scheduled 707 jet flights.

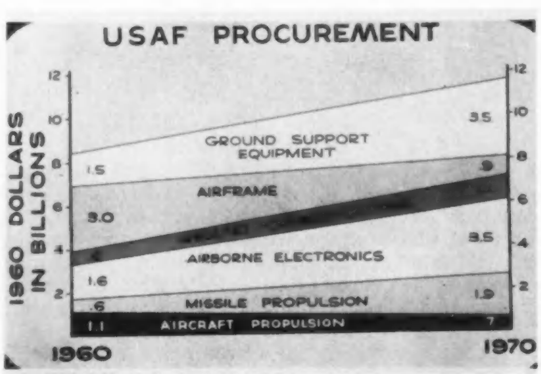
GROSS NATIONAL PRODUCT in the U. S. is expected to rise to $624–806 billion in 1970 from $490 billion in 1959.

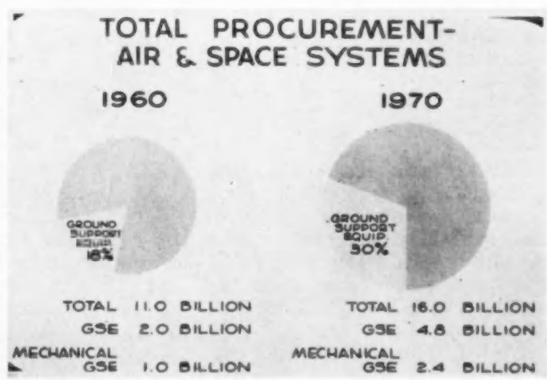
Private capital investment is expected to jump to $70 billion in 1970 from $43 billion in 1959.

A 37% increase in professional, technical, and managerial workers is expected in the next 10 years as compared with a 3% increase in unskilled workers in the same period. In the last half century output per manpower has tripled; employment has doubled; and the work week has been reduced by 25%.

An increasing proportion of contract dollars is being slated for research and development. Spending will approximate $27 billion in 1970 as compared with $12 billion in 1959.

POLYETHYLENE FILM — when exposed to high-energy radiation — undergoes a 500% increase in tensile strength and can be stretched biaxially over 200%. When heated to 180 F, the film returns to its prestretched dimensions. Radiation also raises the temperature to which the material can be exposed and still retain useful physical properties.





GROUND SUPPORT EQUIPMENT COSTS for the USAF ran $1,147 million in 1960, up from $426 million in fiscal 1959, and $275 million in fiscal 1958.

Ground support equipment for a wing of B-58's runs about $30 million. GSE costs for a B-52 wing are estimated at $18 million.

The number of GSE items in a squadron set also have grown rapidly. The F-106 has approximately 3200 items of ground support equipment, the F-105 — 950 items, F-102 — 700 items, and the F-100 approximately 500 items.

Round-up of GEM* Design

Sea-to-shore operation looks promising as development work on ground effect machines points up their advantages and weakness.

THE COMPETITIVE APPLICATION of GEM vehicles is more clearly pinpointed as sea-to-shore, continued development studies show. Here, the ground effect machine is faster than amphibious landing craft and less complex to operate than helicopters.

Four main problems are revealed by development studies:

1. **The design goals** for specific GEM vehicles must be set. At present, these goals are biased by the performance of other types of vehicles. For instance, a 60% gradeability is required for wheeled military vehicles. A similar ability may not be necessary for a GEM because of its greater choice of alternate routes.
2. **Design parameters** must be optimized both for specific applications and for the general improvement of GEM-type vehicles. An example of the latter is the method used to produce the air cushion on which the GEM rides. The simple annular jet or plenum chamber is now being used. When the more complicated mechanical design problems of the labyrinth seal or diffuser-recirculator GEM's are solved, there should be an improvement in the power-to-weight ratio of GEM vehicles.
3. **Stability and control problems** are potential barriers to the usefulness of GEM's. As GEM's lift more than 1/10 of their diameter, they become unstable, while at any height, control must be by air jets, since they can't bank like aircraft or use tire friction like cars.
4. **Operating costs** must be pinned down. The solution to this problem ultimately rests upon the construction and operation of a series of GEM vehicles.

The GEM's Mission

The ability to operate equally well over any relatively smooth and flat surface is the competitive feature that makes the GEM useful for travel over *combinations* of surfaces, be they land, mud, sea, swamp, or snow. One of the largest applications is between the sea and shore, especially as a military vehicle for which special installations are not available. An added advantage is that GEM speeds are in the same order of magnitude as helicopters.

Other applications could include:

- **Arctic vehicle** — The same vehicle could operate over the frozen permafrost, the mud that results when the permafrost thaws, or snow. The light "footprint" that is characteristic of the GEM would permit operation over snow bridges, in fact vehicles have already operated without breaking the crust of a one day old snow.

- **Minesweeping or mine detection** — Floating above the sea or land with little pressure exerted on

*Ground-effect-machine or air-cushion-vehicle (ACV).

GEM Design

. . . continued

the surface makes a GEM an ideal vehicle to detect and eliminate mines.

• **Emergency vehicle** — Shallow water and swamps are places where conventional emergency vehicles cannot operate.

Planning a GEM

Building GEM's large, low-to-the-ground, and with high unit loading will, in general, give the best load-carrying capacity for a given weight and power.

The large vehicle benefits from the fact that its load-carrying capacity goes up in proportion to its area, while the power required increases in proportion to its perimeter. The designer can thus produce a vehicle with four times the gross weight if he doubles his power, other factors remaining constant. However, such a gain is not all payload or fuel, since the structural weight tends to go up as the cube of the perimeter, while the area (or lifting force) climbs according to a square relationship. By getting too big, eventually the payload or range of the GEM suffers. This last factor now precludes large transoceanic GEM's, as long as chemical fuels are used.

The closer to the ground a vehicle hovers, the less the power required to seal the perimeter and maintain high-pressure air under the planform. Within limits, the relationship between height and power is linear. However, if the hovering height is restricted to a couple of inches, the mobility of the GEM is cut. This trade between clearance height and power depends largely on the mission of the GEM. When the clearance height is increased to permit land mobility, part of the lift is actually an annular jet reaction and the augmentation of lift by the planform may drop as low as 1½ times the lift from the jet.

The power required per ton is proportional to the square root of the planform loading, as seen in Fig. 1. This is because the lift increased directly with the total pressure of the annual jet, while the horsepower only increases as the 3/2 power of the total jet pressure. (While Fig. 1 is plotted for an annular jet, it's believed that other GEM systems follow these relationships.)

PROPULSION AND CONTROL — Three methods of propulsion and control using internal air-cushion air are shown in Fig. 2. They are: deflecting the jet, bleeding air, and partially blocking the jet exit. In contrast, there are numerous arrangements of externally applied power and control that do not depend on the cushion air source. The internal methods are limited by the power that can be supplied without affecting the efficiency of the air-cushion system. Fig. 3 shows some of the external methods of applying propulsion and control.

In most external systems, the main propulsive

(continued on page 39)

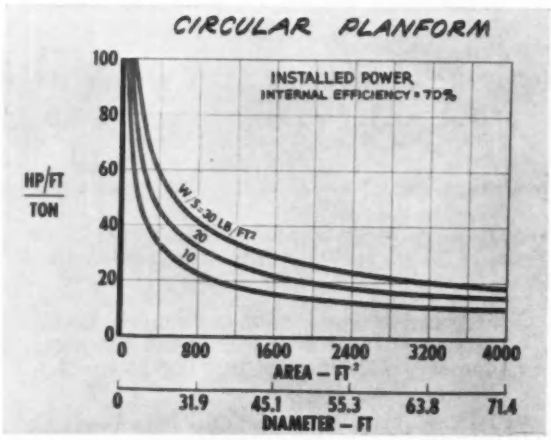


Fig. 1 — Hovering power of a GEM depends primarily on clearance height, planform area, and weight loading. Low flying, heavily loaded, large GEMS are favored from a power efficiency standpoint.

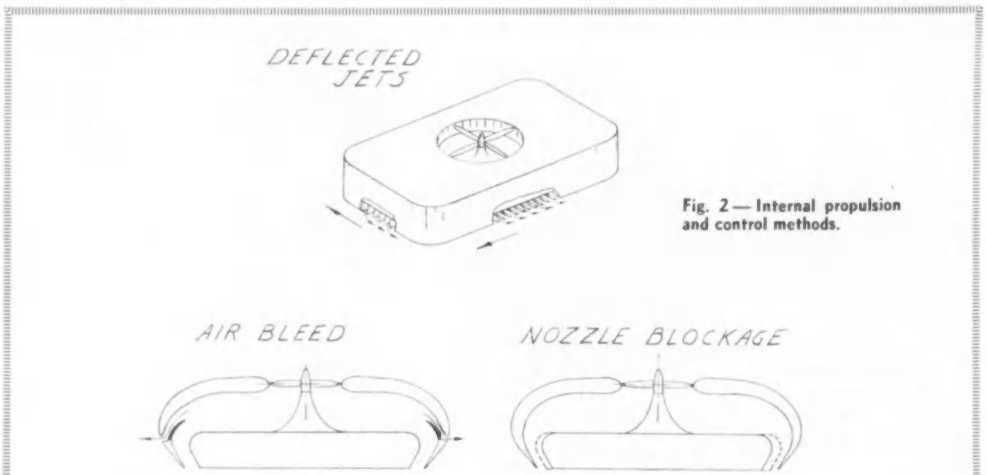


Fig. 2 — Internal propulsion and control methods.

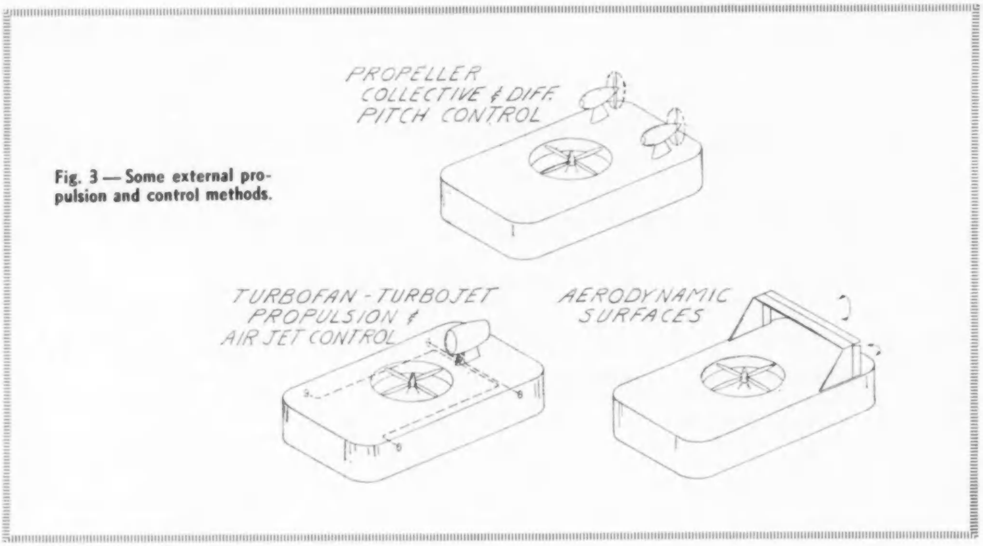


Fig. 3 — Some external propulsion and control methods.

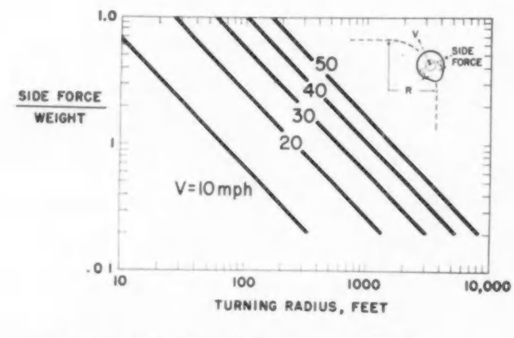


Fig. 4 — Turning a GEM calls for large side forces. It's like making a turn in a car with bald tires on slick ice, or turning a plane without banking.

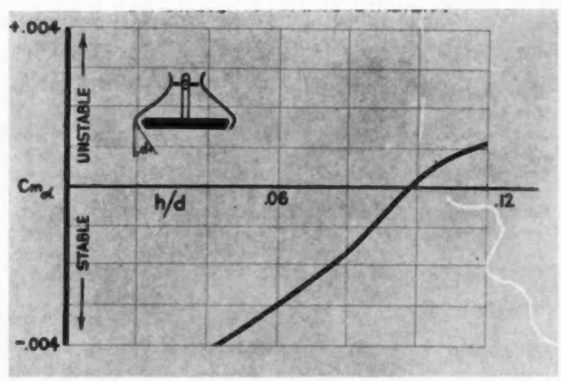


Fig. 5 — Increasing the clearance height-diameter ratio produces instability in pitch and roll for a hovering GEM. A cross flow forms under the GEM that produces a high pressure under the already high side of the GEM.

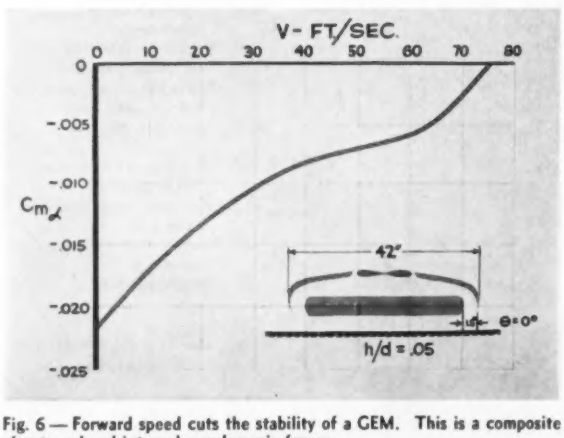


Fig. 6 — Forward speed cuts the stability of a GEM. This is a composite of external and internal aerodynamic forces.

Design details of some existing GEMS, plans, and models

Company	Model No.	Type of Seal	Platform Length, ft	Platform Width, ft	Platform Height, ft	Empty wt, lb	Installed Bhp	Hover Height in.	Max Speed, knots	% Grade	Payload (including fuel), lb	Remarks
1. Aerophysics	GEM II	Peripheral jet	35.3	29.7	12.6	15,000	740	8	50	9	10,000	Design information, not yet demonstrated
2. A.M.F.	—	Peripheral jet	3, 5 ft dia units joined			390	9	1	—	—	195	
3. Anti-Friction Hull	Hydrokeel	Plenum	24	8	5	3,500	185	—	33	—	1,000	Weights and hp approximate
4. Avro, Canada	Avrocar	Peripheral jet	18 ft dia		5	3,426	3,000	36	250	—	2,174	GETOL; max speed is design free flight speed; vehicle not yet flown out of ground effect
5. Bell Aerosystems	2015	Plenum	18	8	4	1,500	65	2	—	1	500	
6. Bell Aerosystems	2033	Peripheral jet	18	8	4	1,700	140	—	—	—	800	Water vehicle, sidewall skegs
7. Bell Helicopter	Air Scooter	Plenum	7.1	4.6	3	190	16	2	24	10	170	
8. Bertelson Mfg.	Aeromobile 200	Peripheral jet	16	8	5.5	1,400	200	12	35	10	800	Design information, not yet demonstrated
9. Bertelson Mfg.	Aeromobile	Plenum	8.4	5.9	2.7	408	72	6	35	—	175	
10. Britten-Norman	Cushioncraft	Peripheral jet	19 ft dia		10	2,000	170	15	35	—	1,000	Max speed not yet demonstrated
11. Curtiss-Wright	ACM 1-1	Plenum	16	11	6	1,050	85	1	20	4	450	
12. Curtiss-Wright	ACM 2-1	Plenum	21	8	5	2,500	300	12	26	8	960	
13. Curtiss-Wright	ACM 2-2	Peripheral jet	21	8	5	2,500	300	9	35	10	960	
14. Curtiss-Wright	ACM 6-1	Peripheral jet	21	8	5	2,300	300	6	55	13	960	Variable width peripheral jet
15. Fletch-Aire	Glidemobile	Peripheral jet	14.2	5.5	3.3	287	72	4	37	4	184	Variable area jet
16. Ford Motor Co.	Levacar	Levapad	7.8	4.5	4	450	16	0.015	13	—	175	Hi-pressure pads (5040 psf); 3 rails for guidance
17. Gyrodyne Co.	55	Peripheral jet	9.2	6	5.4	535	65	6	—	—	260	
18. Saunders-Roe (Westland Aircraft)	SR-N1	Peripheral jet	30	25.5	10.7	10,200	450 + 700 lb thrust	8	48	10	1,000	Uses double peripheral jet
19. Saunders-Roe (Westland Aircraft)	SR-N2	Peripheral jet	63	29.5	21	26,000	3,200	12	70	16	24,000	Design data, vehicle in construction stage
20. Hughes Tool Co.	STV	Water wall	22.6	10.5	8.1	3,402	240	24	22	—	1,760	Side skeg, trapped cushion, bow and stern water wall
21. Hughes Tool Co.	DTV	Water wall	15.7	8.2	4.3	1,630	240	—	—	—	320	All water curtain
22. Nat'l. Res. Assoc.	GEM I	Peripheral	14.6	8.2	4.3	1,050	80	14	22	7	250	Max power developed 66 hp
23. Nat'l. Res. Assoc.	GEM III	Peripheral	24	12	7.1	1,430	140	18	26	10	320	Design data, vehicle in construction stage
24. Princeton University	X-3	Peripheral	20 ft dia		4	850	48	14	22	—	220	
25. Princeton University	X-3B	Peripheral	20 ft dia		4	1,150	180	24	—	—	450	Four radial stabilizing slots
26. Princeton University	X-4	Peripheral	9 ft dia		4	200	15	3	17	10	200	Flexible cloth skirt
27. Princeton University	X-2	Peripheral	8 ft dia		4	120	5	5	10	0	180	Flexible cloth skirt
28. Spacetronics	—	Plenum	18	9	?	800	—	4	—	—	200	
29. Spacetronics	Hydro-Aire	Plenum	30	24	5	4,500	270	14	47	—	4,000	Performance quoted but not demonstrated
30. Goodyear Aircraft	—	Plenum	8	5	5	750	35	1	—	—	250	Flexible airmat under-structure no forward propulsion
31. Folland Aircraft	GERM	Peripheral	15	8	4.5	1,300	95	—	42	—	300	Two concentric jets, max speed not yet demonstrated
32. Vickers (So. Marsten)	3031	Peripheral	47.5	20.1	?	10,500	1,000	18	60	—	6,000	Design data, vehicle in construction
33. Valmet Corp.	KAAR10 V-8	Plenum	14	6	10	650	18	—	38	10	400	Speed not yet demonstrated, ram wing concept
34. D.T.M.B.	448	Peripheral	8.3	3.3	1.5	—	—	—	—	—	—	Wind tunnel model, propulsive vanes in jet
35. D.T.M.B.	463	Peripheral	15	6	2	240	10	8	20	—	—	Dynamic flight model, propulsive vanes in jet
36. D.T.M.B.	472	Peripheral	6	3	1.5	—	—	—	—	—	—	Wind tunnel model
37. Carl Weiland (Grogg's Inc.)	ILEN	Peripheral	33	30	7	14,000	720	16	60	0	2,420	
38. Grumman	—	Peripheral	10	5	4	650	140	14	42	25	880	Stability model, design data, in construction stage

force will be tailored to produce forward motion. However, the GEM is particularly difficult to design because large forces are needed for control, such as braking and turning, since there is no tire reaction or banking possible. An example of the turning forces that must be generated by aerodynamic means is shown in Fig. 4. At 40 mph, a side force equal to the vehicle's weight is needed to make a 100-ft radius turn.

The problem of control forces is again demonstrated by a GEM climbing a grade. All is well as long as the vehicle is going straight up the grade, but when the driver steers across the grade, his main control force must be at right angles to the vehicle. It is possible to "crab" the vehicle, but this will make driving more difficult and may not be possible in some terrains. To get near the accelerating ability of a modern car, the GEM needs roughly three times the power loading (hp/lb).

STABILITY — Air-cushion vehicles tend toward instability in pitch and roll as the ratio of clearance height to planform diameter (h/d) exceeds 0.05. The reason for this, in the case of the annular jet, is that the jet on the low side splits and part of the air cross flows under the vehicle to the high side. The tilted vehicle acts as a diffuser producing dominating high pressures on the already high side of the vehicle.

Both physical and air-curtain partitions are used to prevent this cross flow with success at clearance height ratios up to 10%. However, as the height increases, the effect of the partitions decreases. Forward velocity also tends to make the GEM unstable, but this effect is a combination of both internal and external aerodynamic forces. Examples of the stability of simple annular jet GEM's are shown in Figs. 5 and 6.

Other factors such as planform shape, jet thickness, and jet angle do not have large effects on stability. If the partition method is not suitable for the clearance height desired, secondary control systems producing artificial stability will have to be used.

DEBRIS — Annular jet and plenum machines have a constant efflux of high-velocity air, which

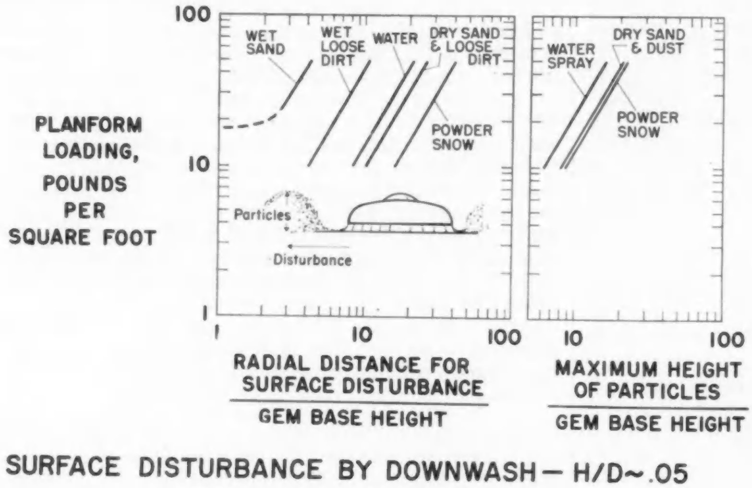


Fig. 7 — Debris is thrown by the cushion air escaping from beneath a GEM. The range and height of typical debris are shown.

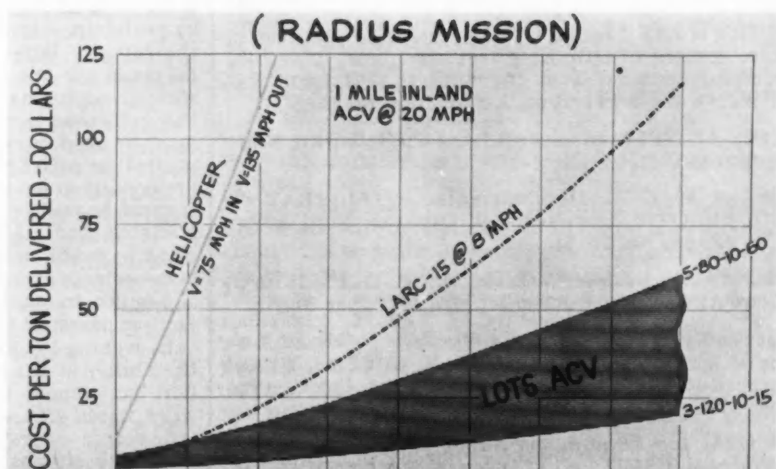


Fig. 8 — Air-cushion vehicles fit between helicopters and amphibians in mobility, but look to be more economical than either in a logistics-over-the-shore mission.

GEM Design

. . . continued

kicks up any loose surface material, including water. This problem is also encountered with the recirculating air type of machine since in this case the debris is circulated through the machinery.

Two partial solutions are to operate at a low base pressure and to install deflectors around the vehicle. The first reduces the exit velocity of the air, and the second aids visibility by keeping the debris low to the ground. The deflectors are especially useful with water-going GEM's, since a fog or mist is formed by the escaping air cushion. The height and distance common debris is thrown are shown in Fig. 7.

Operating Costs

A wide band of costs must be assigned to air-cushion vehicles since precise operating costs are not yet available. Even with broad assumptions, the GEM shows dollar advantages to present methods of moving military goods from ships at sea to over-the-shore destinations. This is shown in Fig. 8, where an air-cushion vehicle, a helicopter, and the amphibian LARC are compared. The gray area assigned to the Logistics-over-the-Shore air-cushion vehicle represent:

- Clearance height of 3–5 ft.
- Speeds of 80–120 mph.
- Maintenance cost of 15–60% of initial cost per year.
- Initial cost at $10/lb for structure and $60/lb for engines.

One advantage of the GEM not shown is the ease of overload when conditions allow small ground clearances.

This is SAE Journal's 1961 roundup of progress in development of Ground Effect Machines. The 1960 roundup, published in the March, 1960 issue was titled, "6 Ways to Lift an Air Cushion Machine."

THIS ARTICLE was drawn from the following presentations:

Status of GEM Developments, by MURRAY F. SOUTHCOTE, Aeronautronic Division, Ford Motor Co. **(Paper No. 270A)**

Marine Air Cushion Vehicles, by P. G. FIELDING, Booz-Allen Applied Research, Inc. **(Paper 270B)**

Ground-Effect Machine Applications in Mixed Terrains, by M. M. CUTLET and A. K. KOSSAR, Wright Aeronautical Division, Curtiss-Wright Corp. **(Paper 270C)**

A GEM for Amphibious Support, by Lt.-Col. J. L. WOSSER, USMC, and Lt.-Com. A. J. VAN TUYL, JR., USN, Air Programs, Office of Naval Research. **(Paper 270D)**

To order any of these papers, see p. 6.

Supersonics

if economics

Based on paper by

S. M. Horowitz

Convair San Diego

Is the building of a supersonic transport a wise undertaking? This question is currently of great concern to the air industry. It is conceded that such an aircraft will be costly. Every item in its array of costs will probably be more expensive than subsonic costs, but they may be justified by the supersonic transport's productivity. An airplane's productivity is its ability to make trips. If a supersonic transport with twice the daily costs of operation as a subsonic transport can make twice as many trips per day, it begins to be economically attractive.

Just what type of aircraft might be feasible for profitable supersonic operation was the subject of a recent study. The most favorable type of aircraft appears to be one having a large seating capacity, long range, and possibly flying at Mach 3.

Luring revenue

To compute the profits that might be expected from the supersonic transport, revenues and costs must be predicted. Revenue inputs may be obtained by projecting current passenger travel statistics into the future. When doing this some allowance must be made for the effect of added speed on people's willingness to pay. The additional revenue lured by the better service of the more productive aircraft must be accounted for. Care must also be exercised in dealing with the available statistics. These data are usually given in terms of average monthly totals. It must be realized that the actual demand for seats is distributed about this average. An examination must be made of the trade-off between operating a large vehicle at low load factors during off-hours at a penalty in operating costs, with the cost of rejecting passengers during peak hours.

In seeking to determine the optimum aircraft size, the ability of the various cities of the world to support supersonic travel was evaluated. The cities were paired off and their separating distances noted. Supersonic operation was considered feasible only for those city pairs capable of supporting a daily round-trip schedule.

The results of this analysis do not favor the smaller aircraft. Rather, the larger, lower cost per seat-mile, vehicles were considered best. For the

to fly

allow

domestic portion of the world's air travel it was found that city pairs either qualified in a big way or not at all. The effect of lowering the passenger requirements by using smaller vehicles did not substantially affect the number of cities that could be serviced. Approximately 75 domestic city pairs were found to be capable of supporting a daily round trip schedule in 1970 for a large supersonic transport operating with respectable load factors.

The matters of aircraft range and velocity are determined from considerations of utilization. As the number of trips per day increases, the proportion of ground time taken out of the useful day increases. On the other hand, the aircraft can be more efficiently scheduled when the number of trips per day increase, due to shorter block time. It was found that on short-range trips the utilization potential was severely curtailed. But, for most ranges, the potential utilization exceeded present airline experience. An estimate of the effect of range on productivity shows a Mach 3 transport traveling over a 4000 nautical mile route at 142% increase in trips over a current jet. This advantage reduces to 65% at a 1000-mile range.

Since productivity is so important in determining the revenues, any reduction of nonproductive time will help. It is apparent, then, why recommendations for a complementary system to reduce ground delays are made for supersonic transports. These include more rapid handling of passengers and baggage as well as more advanced air traffic control systems. In addition, if a longer useful day can be made available to the supersonic transport, the penalty from lower utilization, which becomes critical at shorter ranges, can be reduced. A smaller allowance for maintenance will provide this. The plan to incorporate an in-flight maintenance program logically follows from this consideration.

A potentially hazardous limit to supersonic transport utilization does exist. . . . sonic boom. If this results in the curtailment of the hours of the day available for supersonic flight, supersonic productivity will be seriously affected. This results in pressures to operate at longer ranges in order to derive greater aircraft utilization. This conclusion is enhanced by the fact that the solution to the sonic boom is likely to result, as well, in an eccentric climb and descent profile. Since this profile will not vary with trip length, longer range is again indicated.

One other factor operating against short-range operation is that there would be smaller demand for supersonic travel when the block time is comparable to the normal delay and travel times to and from the terminal.

The cost picture

Profit will only be made if the costs of supersonic operation can be kept at a lower level than the revenue. But even before the point is reached where profit can be contemplated, the aircraft must be built and bought. To some extent the manufacturer is limited by the costs of research and development. His financial back may very well be broken by attempting to build the supersonic transport, if these costs run out of hand.

After the plane is built, it must be purchased. The ability of the airlines to purchase a particular aircraft design very much depends upon the price that is charged for it. This price is an obstacle to be overcome by an airline's ability to finance capital improvement.

Once the aircraft is in service the cost of operation will determine the success of the venture. A recipe for computing direct operating costs has been concocted by the Air Transport Association from ingredients which are known early in the aircraft's development. This formula can be extrapolated to suit supersonic transport operations. The cost categories which are included are (1) depreciation of aircraft and related equipment (2) flight crew salaries (3) fuel costs, and (4) maintenance costs. These may be summarized to yield a direct cost per trip for the various types of route segments considered. One more cost must be considered, that brought on by off-design operation.

One of the facts of supersonic life is that fuel consumption costs become a larger portion of operating costs. Supersonic break-throughs, if they occur, may well take the form of improved fuel consumption characteristics.

According to the ATA formula, fuel consumption was found to represent about 50% of the supersonic transport's direct operating cost. This contrasts with 22% for subsonic jets. In addition to the normally higher fuel costs, there is a more rapid increase in off-design fuel costs compared to subsonic aircraft. For example, the costs per mile for supersonic and subsonic transports are practically identical at a common design range of 3500 n. miles. Off-design operation at a range of 1000 n. miles boosts supersonic costs 25% above the subsonic transport.

Besides the increased off-design fuel costs there are increased rental costs per mile with the supersonic aircraft. This is due to its relative inability to make additional shorter range trips.

Equipment, salaries, and maintenance expenses are relatively independent of mileage and can be thought of as a sort of fixed rental. This rental cost per mile can be reduced by increased usage. On the contrary, fuel costs per mile are constant, so no reductions accrue through increased flying.

Although a potential profit is seen to exist in supersonic flying, there are other points to be considered which may not be so readily evaluated. Is the venture worth the investment exposure? What hedges against this exposure will the government provide? Does this represent the best outlet for the industry's investment funds?

To Order Paper No. 239A . . .
from which material for this article was drawn, see p. 6.

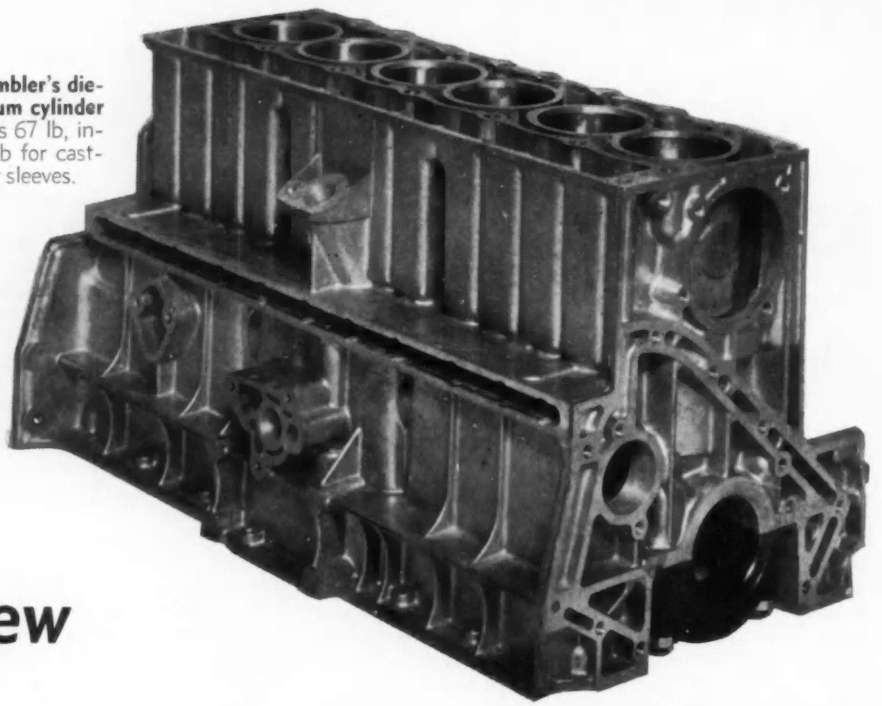


Fig. 1 — **Rambler's die-cast aluminum cylinder block** weighs 67 lb, including 14 lb for cast-iron cylinder sleeves.

4 New aluminum cylinder blocks

. . . in engines for 1961 U.S. models.

Two are die-cast. Two combine with cast iron cylinder heads; two with aluminum. All use cast iron cylinder liners.

FOUR new "aluminum" engines made their appearance in 1961 U. S. passenger cars. Chrysler Corp. has its slant-6 engine in limited production for its Plymouth, Valiant, Dodge Dart, and Dodge Lancer cars. The others are made by Oldsmobile, Buick, and American Motors.

Both the Rambler and the Chrysler slant-6 engines have die-cast aluminum cylinder blocks with cast iron liners. Buick and Oldsmobile have aluminum cylinder blocks made by the semi-permanent mold process, and use cast iron liners. In both Buick and Oldsmobile, sand cores are used for water-jacket and port cores.

In all four engines, of course, the cylinder block is the largest and most intricate part made of aluminum; the part in which are illustrated new combinations of design, testing, and manufacturing techniques; the part which characterizes them as "aluminum engines."

So, the problems of design and correlation with production requirements — as regards the cylinder blocks and heads — faced and met by these four different engineering groups have special significance.

The Rambler aluminum cylinder block (Fig. 1) weighs 67 lb, of which 14 lb is accounted for by the iron cylinder sleeves. (A cast iron cylinder head is used.) The comparable as-cast weight of the production cast-iron block is 166 lb. As machined and with bearing caps the aluminum block weighs 70.9 lb; the cast iron block, 142 lb.

Test experience with the Rambler block indicated that hydraulic tappets were desirable to compensate for the expansion of the block relative to the push rods. The oil supply for each tappet is provided by feed holes from a main oil gallery cast in the block. (The unusual size and shape of this gallery requires minimum machining and allows intersection of all vertical cored oil holes.) A bolted-on die cast aluminum cover seals the oil gallery which, as cast, is entirely open on one side.

Short drilled holes intersect the main bearing bolt holes, and these cast holes in turn intersect the main oil gallery to provide oil to the main bearings. A

"THE CYLINDER BLOCK, being the largest individual structural component of the engine, offered the greatest potential for weight savings through the use of aluminum," Buick's J. D. Turlay said recently while telling the full technical story of Buick's new aluminum engine.

Chrysler's E. G. Moeller, American Motors' J. F. Adamson, and Oldsmobile's Gilbert Burrell implied agreement as they described to the same SAE audience new aluminum engines for 1961 models which each of their companies has developed.

This article is drawn almost entirely from SAE Papers #307A, 307B, 307C, and 307D, in which engineers from American Motors, Buick, Chrysler Corp., and Oldsmobile dealt with important cylinder block problems as one facet of complete technical descriptions of their four new "aluminum" engines.

To order these complete-engine-description papers 307A (American Motors); 307B (Buick); 307C (Chrysler); 307D (Oldsmobile) . . . see p. 6.

To order Paper 307E — which describes Pontiac's new 4-cyl Tempest engine . . . or Paper 307F — which tells details of Studebaker's new Lark VI overhead-valve engine . . . see p. 6.

cored oil hole intersects the main oil gallery to provide oil for the cam bearing. Die cast oil passages have been provided wherever possible.

Oil pump capacity was increased by 40% over that used in the cast iron engine to insure an adequate supply of oil for bearings, hydraulic tappets, and other engine requirements.

This pump was designed with an integral full-flow filter positioned in a horizontal plane for easy servicing from the engine compartment. The horizontal configuration also prevents an accumulation of dirt at the oil entrance to the filter element.

The crankcase ventilation system utilizes a cast passage on the left side of the crankcase. Here an attachment is provided for the road draft tube or the optional positive-type crankcase ventilation system.

A new nine counter-weighted crankshaft was designed to improve engine balance, and to reduce main bearing load reactions.

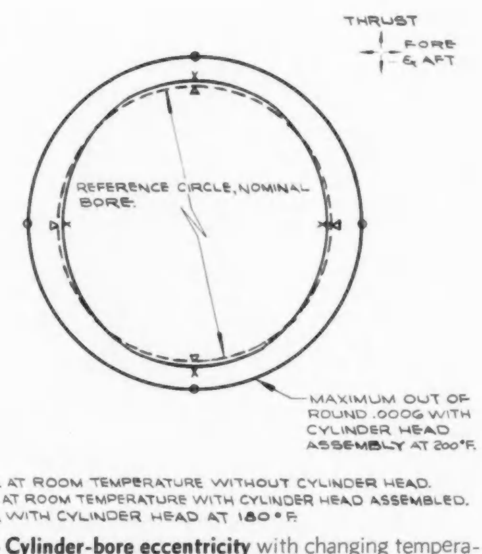
A wedge-type lock that allows the iron cap permanently to deform the entrance corners of the slot in the aluminum crankcase locks the main bearing cap to the aluminum block. This arrangement allows the cap to be disassembled and reassembled, and the honed radial alignment of the cap to the block to be held.

This Rambler aluminum cylinder block does not have a continuous top deck. The design is a major departure from previous American Motors production engines in having these "free-standing" bores. In completing this phase of the design, American Motors engineers had to give special attention to:

- Construction of the cylinder head gasket.
- Dimensional stability of the cylinder barrels under operating conditions (the degree of bore distortion encountered).
- Effects of the high rate of expansion of aluminum.

Design of the cylinder head gasket and location — as well as design of cylinder head attaching bosses — had significant effects on the pattern of direction of cylinder bore eccentricity with changing temperatures, as shown in Fig. 2. The final design represents a culmination of many rejected constructions.

Basic design requirement for the Rambler cylinder head gasket was to get enough assembly pressure at the combustion chamber grommet to seal explosion pressure. To prevent distortion of the block's crankcase area, the free-standing bores are loaded in



Δ BLOCK AT ROOM TEMPERATURE WITHOUT CYLINDER HEAD.
X BLOCK AT ROOM TEMPERATURE WITH CYLINDER HEAD ASSEMBLED.
O BLOCK WITH CYLINDER HEAD AT 180°F.

Fig. 2 — **Cylinder-bore eccentricity** with changing temperatures in new Rambler aluminum engine.

Aluminum cylinder blocks

. . . **continued**

compression by the cylinder head assembly. This load is transferred to tension in the sidewalls through the crankcase section of the block.

Rambler's use of a cast iron cylinder head with its aluminum block brought the problem, of course, of combining cast iron and aluminum. The cast iron head, for example, has a change in overall length of 0.035 in. from – 20 F to 220 F. The aluminum block changes in overall length 0.065 in. over the same temperature range. The problem: What happens to the 0.030 difference in expansion when the units are bolted together?

The answer given by American Motors engineers runs as follows: The iron head restrains, to a degree, the expansion of the aluminum block. Also, there probably is a minute amount of slip between the two parts, regardless of the clamping pressure of the cylinder-head cap screws. Experience shows that aluminum cylinder heads have been used with cast iron blocks in the past — with reasonable success. So, the aluminum-block, cast-iron-head engine was built, run under all conceivable conditions, and the results analyzed.

As a result, ASTM S 12A aluminum alloy was selected for the die-cast block. In addition to producing sound castings, this alloy was chosen as having optimum physical properties, minimum shrink, machinability, and good resistance to corrosion.

Chrysler's Slant-6 Aluminum Block

The aluminum cylinder block in Chrysler's slant-6 engine also is die cast . . . and a cast-iron cylinder head is used.

Design and evolution of this Chrysler die cast aluminum cylinder block was developed as illustrated in Figs. 3 through 9.

Fig. 3 shows the bottom side of the block. The die forming the three crankcase bays also supports 6 mandrels, on which the cylinder sleeves are placed during casting. This die forms the bulkheads with a minimum of unnecessary metal. The 2-piece, bolted-in bearing cap construction permits this. This part of the die also forms the tappet bosses as shown in Fig. 3. The insides of the tappet bosses are cored out, as are the end camshaft bearing.

A top view of the Chrysler block is shown in Fig. 4. The water jacket and the core forming the tappet chamber are both mounted on the ejector half of the die. They pull out from the top.

The combined thickness of iron and aluminum which makes up the cylinder bore is 0.21 in., and the engine is designed on a 3.98-in. bore center spacing. This, in conjunction with a 3.40-in. diameter cylinder bore, provides a minimum water jacket thickness of 0.16 in. between cylinder bores. These dimensions are necessary to minimize engine length and to machine this engine using the same tooling as is used for its cast-iron companion.

Fig. 5 shows the left side of the Chrysler cylinder block. The blending of the cylinder-head capscrew bosses into the water jacket wall is illustrated . . . also the generous ribbing in the area of the integral water pump housing and the rear flange of the cylinder block.

The right side of the block is shown in Fig. 6. This view shows how the tappet chamber wall is cored into the water jacket wall at the base of the cylinder head bolt bosses. The main oil gallery of the engine is shown running longitudinally along the block. The individual bosses may be used to provide oil to each of the tappet bores. However, this feature is not used in this engine with mechanical tappets. The oil pump, distributor, and fuel pump are mounted on this side of the block on the bosses indicated.

Figure 7 illustrates how the rear face of the block is cored out to get maximum rigidity for mounting the clutch or transmission housing, while maintaining minimum weight. The rear camshaft bearing is closed off with an aluminum-cup-type plug as shown. Adjacent and slightly to the right is the steel flange-type plug which closes off the end of the oil gallery.

Figure 8 shows the front surface of the cylinder block, with the integral water pump housing on the

Design features of die-cast for Chrysler Corporation's

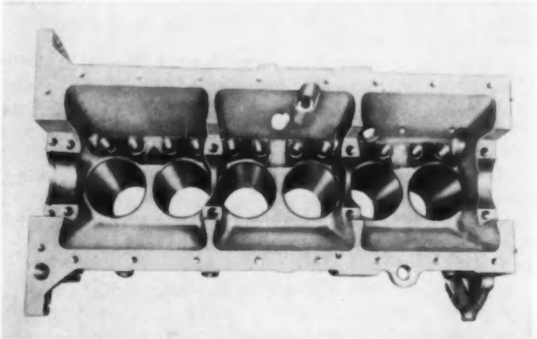


Fig. 3 — **Bottom view** of Chrysler die-cast aluminum cylinder block.

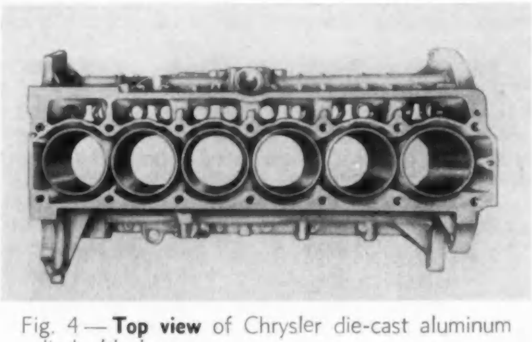


Fig. 4 — **Top view** of Chrysler die-cast aluminum cylinder block.

left front. The water pump scroll outlet leads directly into the lower portion of the water jacket surrounding the cylinders. The chaincase cover flange is also illustrated in Fig. 8. The cored hole in the upper center of this area is needed for crankcase ventilation. The camshaft journals run directly upon the aluminum block material. The small aluminum cup-type plug, to the left of the camshaft bearing, closes off the front end of the oil gallery.

The fully machined cylinder block weighs 64 lb. A bottom view of the Chrysler block is shown in Fig. 9. Here, the main bearing caps and the rear-seal retainer caps are assembled in position. Both the upper and lower cast iron bearing caps are a press fit in the cylinder block. The upper bearing cap and the cylinder block are so machined that contact never occurs between the cap and the block on the circular segment between the fastening holes. As a result, contact always occurs as desired at the screw boss, and thermal — as well as fastening — load distortion is minimized.

The No. 3 main bearing takes the crankshaft thrust load and is positioned by a hollow dowel as

aluminum cylinder block

new slant-6 aluminum engine.

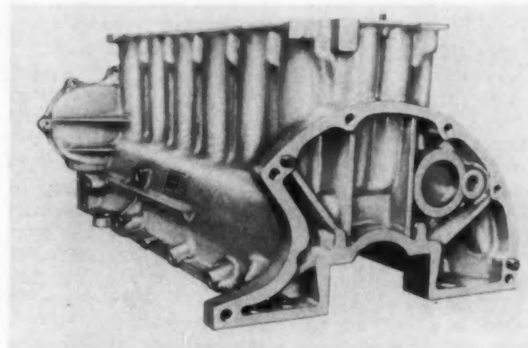


Fig. 7 — **Rear face view** of Chrysler die-cast aluminum cylinder block.

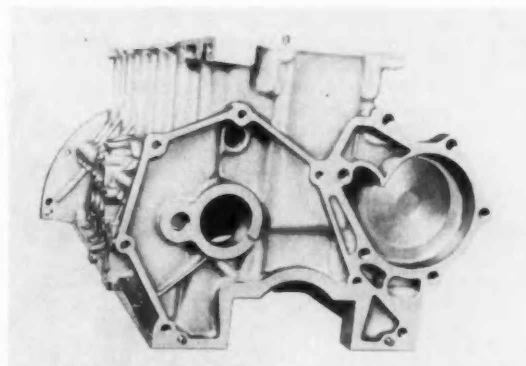


Fig. 8 — **Front face view** of Chrysler die-cast aluminum cylinder block.

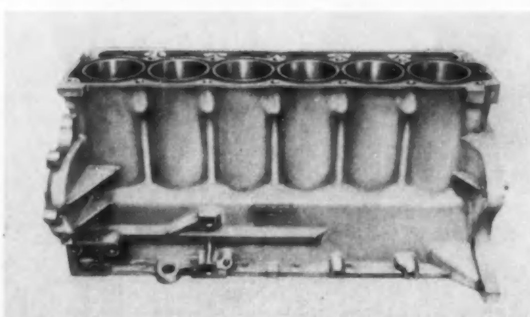


Fig. 5 — **Left side view** of Chrysler die-cast aluminum cylinder block.

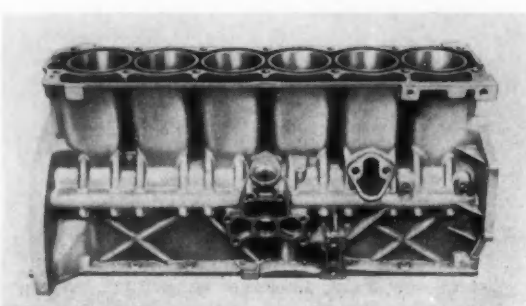


Fig. 6 — **Right side view** of Chrysler die-cast aluminum cylinder block.

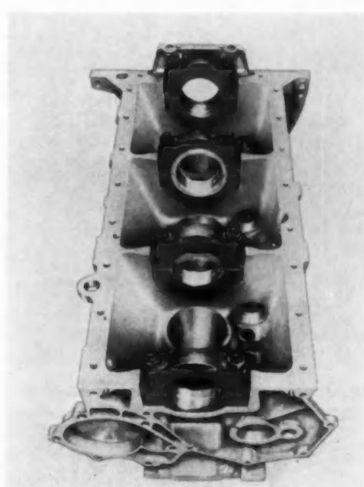


Fig. 9 — **Chrysler die-cast aluminum cylinder block** with bearing caps in place.

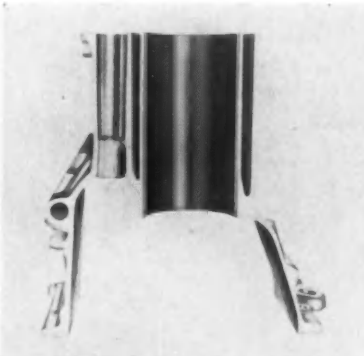


Fig. 10 — **Chrysler die-cast aluminum block** is cast around the cylinder sleeves.

Aluminum cylinder blocks

. . . continued

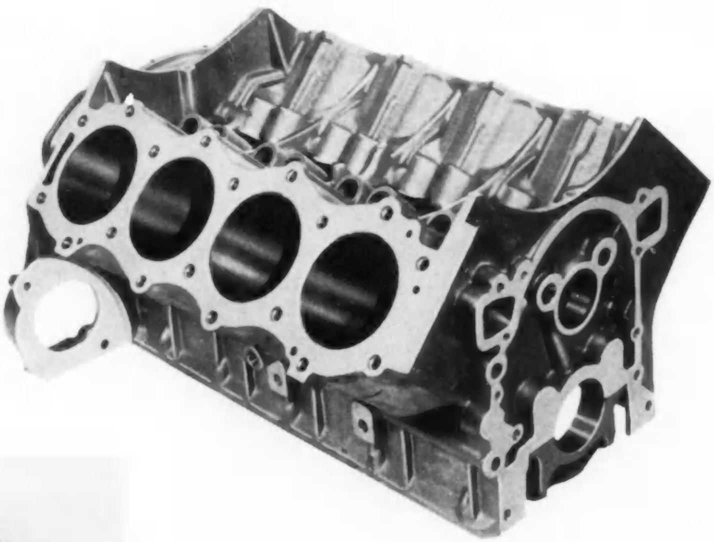
shown in the center of Fig. 9. The upper and lower retainers which support the crankshaft rear seal are a loose fit in the cylinder block and form an oil seal with the molded rubber parts as illustrated.

The main bearing shells are basically interchangeable with those used in Chrysler's cast-iron-cylinder-block engines.

Block Cast Around Liners

The Chrysler aluminum cylinder block is cast around the cylinder liners, with the result shown in Fig. 10. The iron cylinder liner is 0.10 in. thick; the aluminum around it is 0.11 in. thick at the top of the bore — where the aluminum is thinnest due to the 0.5 deg draft of the water-jacket core.

Fig. 11 — **Buick aluminum cylinder block,** made by semi-permanent mold casting process is used in new Buick V-8 aluminum engine. Used also is aluminum cylinder head.



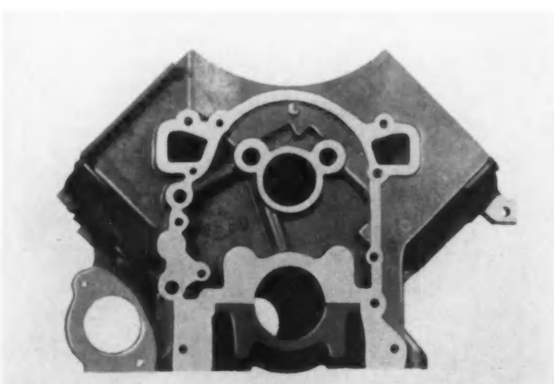


Fig. 12 — **Oil-pan mounting** surface is 2.25 in. below the crankshaft centerline in new Buick aluminum engine.

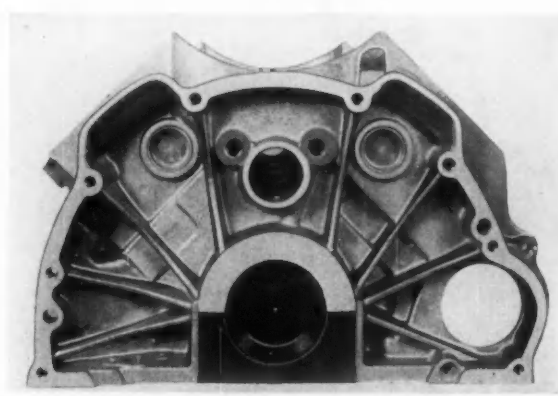


Fig. 13 — **In new Buick aluminum engine,** the mounting surface for both automatic and synchromesh transmissions is the ribbed, deep-section flywheel housing end of the cylinder block.

Considering the maximum overall wall thickness of 0.21 in., the relative thickness of the iron and aluminum is influenced by:

- Production variations in liner location, which, between casting and machining, produce maximum liner thickness variations of ± 0.030 in.
- Boring out the cylinder liners in service, which reduces the wall thickness another 0.020 in.
- Thin aluminum walls, which make it difficult to produce good quality castings, and also increase the residual stresses.
- Any consideration of reducing water-jacket core thickness of 0.16 in. at the top of the cylinder bores to increase the cylinder wall thickness beyond 0.21 in. incurred an impractical die-life-expectancy . . . and an objectionable degree of cylinder siamizing as influenced by the taper of the die for draft requirements.

So, 0.10-in.-thick liners and 0.11-in.-thick aluminum walls were chosen to get the best overall result.

Buick's Aluminum Cylinder Block

The aluminum cylinder block in Buick's new V–8 "aluminum" engine is made by the semipermanent mold casting process, as is the aluminum cylinder head used in this engine.

This Buick block, shown in Fig. 11, also incorporates cast-in-place cast-iron sleeves. This aluminum block has the dropped pan rail long characteristic of Buick engines. The oil-pan-mounting surface is 2.25 in. below the crankshaft centerline (Fig. 12). This configuration gives a continuous, flat oil-pan mounting and permits mounting the starter directly in the cylinder block for added rigidity.

The mounting surface for both the automatic and synchromesh transmissions is at the ribbed, deep-section flywheel housing end of the cylinder block (Fig. 13). This deep-block feature increases the natural frequency of the engine-transmission assembly in vertical bending. This provides a smoother installation, because it is well above the normal frequency range of the rest of the vehicle.

Two air inlets in the flywheel housing — for the air-cooled dual-path transmission — are covered by the die-cast flywheel and clutch housing when the synchromesh transmission is specified.

Cast iron main-bearing caps are used with this aluminum cylinder block. They control main-bearing clearances throughout the operating tempera-

Six New 1961-Model Passenger Cars

ENGINE	No. of cylinders and type	Valve arrangement	Bore and stroke	Piston displacement, cu in.	Compression ratio (to 1)	Cylinder block		Cylinder head		Cylinder sleeves	Pistons	
						Material	Casting method	Material	Casting method	Material	Material	Casting method
"Aluminum" Engines												
RAMBLER	6-in-line	OH	3.125 × 4.25	196	8.7	al	die cast	ci	sand	ci	al	
CHRYSLER CORP.	6 — 30° tilt	OH	3.40 × {3.12 / 4.12}	{170 / 225}	8.2	al	die cast	ci	sand	ci	al	FP
BUICK	V-8	OH	3.50 × 2.80	215	8.8	al	SP	al	SP	ci	al	FP
OLDSMOBILE	V-8	OH	3.50 × 2.80	215	8.75	al	SP	al	SP	ci	al	FP
"Cast Iron" Engines												
STUDEBAKER LARK VI	6-in-line	OH	3.0 × 4.0	169.6	8.50	ci	sand	ci	sand	—	al	FP
PONTIAC TEMPEST*	4 — 45° tilt	OH	4.06 × 3.75	195.5	8.6	ci	sand	ci	sand	—	al	FP

*A V–8 aluminum engine is also offered as optional in the Tempest

OH — Overhead valve
SP — Semi-permanent mold
FP — Full permanent mold
al — Aluminum
ci — Cast iron

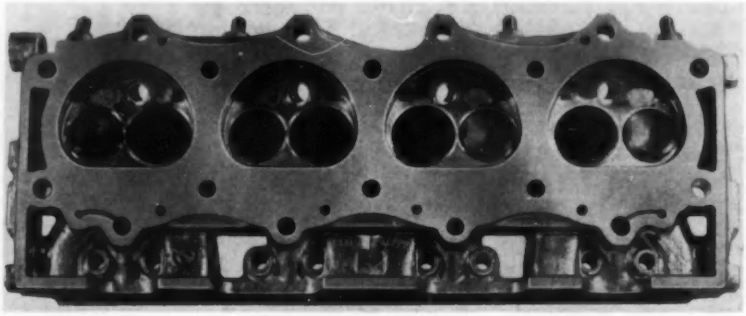


Fig. 14 — **Cylinder head in Oldsmobile aluminum engine** is also made of aluminum and is cast by semi-permanent mold process.

Aluminum cylinder blocks

. . . **continued**

ture range. A 67% increase in the moment of inertia of the cap cross section (in the final as compared to the original design) reduced greatly the problem when the higher expansion rate of the aluminum caused the horizontal clearance of the bearing to change at a faster rate than the vertical clearance when temperatures changed.

Buick engineers also had to overcome the problem of bolt torque versus clamping load characteristics of aluminum threads. Repeated assembly of untreated bolts in the aluminum threads resulted in a substantial reduction in clamping load for a given bolt torque value. . . . The loss in load caused a change in main bearing bore diameter between machining and engine assembly since the bearing caps are removed and reinstalled. A minimum thread engagement, equivalent to twice the bolt diameter was adopted for all bolts threaded into aluminum to permit utilizing the load-carrying capacities of the respective bolts.

Water-jacket depth in the Buick aluminum cylinder block is only 4.06 in. as compared to an overall bore length of 5.56 in. This gives a reduction in heat ejected to the cooling water and quicker warmup, while providing adequate cooling capacity, Buick engineers found. Only one cored opening through the cylinder-head deck from the water jacket is provided at the rear of each bank. Result: a minimum of openings for potential cylinder-head gasket water leaks. (The cylinder head bolt pattern of five bolts per cylinder results from satisfactory experience with this pattern on Buick's larger cast-iron V–8 engines.)

A 0.015-in.-thick aluminum-coated-steel, beaded cylinder-head gasket is used. It is interchangeable between cylinder banks. Double heads are provided around the cylinder bores for added protection in these critical areas.

Buick's Cylinder Head

The aluminum cylinder head — made by semi-permanent mold casting — has a one-piece water jacket core, which eliminates a pasted core assembly and reduces the number of cores needed from the core room. . . . Valve-seat inserts of alloy cast iron are assembled into the cylinder head by a shrink-fit process. Separate, pressed-in-place alloy-iron valve guides complete the cylinder head assembly.

Oldsmobile V-8 Aluminum Cylinder Block

Like the Buick, Oldsmobile's new V–8 aluminum engine has both cylinder block and cylinder head (Fig. 14) made of aluminum — by semi-permanent mold process. Both the block and the head are cast of 356 aluminum (silicon: 6.5 — 7.5; copper: 0.20; iron: 0.50; zinc: 0.20; manganese: 0.10; magnesium: 0.20 — 0.40; titanium: 0.20). Because of available manufacturing facilities, Buick manufactures the cylinder block and rotating parts for this Oldsmobile aluminum engine.

The Oldsmobile aluminum cylinder block is a rigid, deep-skirted design which makes for a connection between engine and transmission which keeps the natural frequency of the combined units very high to eliminate vibration periods, as with Buick. In the Oldsmobile also, cast iron sleeves are cast-in-place in the cylinder block.

The aluminum cylinder heads are attached to the aluminum block by six 7/16-in. bolts per cylinder. Embossed steel head gaskets are 0.020 in. thick. Exhaust manifolds are attached to the cylinder heads by studs to prevent loosening from the constant thermal expansion and contraction. The cylinder heads are symmetrical, so they can be used on either the left or the right side of the engine.

. . . **To order, see p. 6.**

Plastics continue *Auto Market* penetration

1961 models feature many new and unique plastic applications. *Future holds even greater promise.*

Based on report to
SAE Engineering Materials Activity Committee by

John D. Young

E. I. du Pont de Nemours & Co., Inc.

PLASTICS continue to make inroads in the automotive industry. Further penetration of applications traditionally held by other materials continued with the 1961 models.

Outstanding among a number of new uses for plastics in the 1961 models is a complex new instrument cluster housing for the 1961 Valiant. The part, made of acetal resin, supports 10 lb of instruments and controls. Temperatures up to 225 F must be resisted. The light weight plastic part must also resist cold-flow under continuous load.

Valiant is also using first-surfaced metalized acrylic as a decorative bezel around the instruments.

A parallel application is the use of an acrylic resin and a heat-resistant ABS resin for an instrument housing for a 1961 truck and another 1961 "Compact."

Automotive engineers are now giving serious consideration to designing and building entire instrument panels out of plastics. Lightness of weight, lack of finishing operations, unlimited surface textures, colorability, and opportunities for molded-in electrical circuits are mentioned as valid reasons for using plastics for this application.

Another interesting new application for plastics in the 1961 cars involves plastic rug-backing. With the plastics backing, floor rugs for cars can now be vacuum-formed to provide a proper-fitting, contoured rug shape. Rug wear is also improved. Polyethylene backing is used.

Meanwhile, applications for plastic mechanical parts continue to grow. Today, nylon is being used for gears, cams and ratchets for windshield wipers, power-seats, and power-windows. Bearings for moving parts in window regulators, door latches, and seat adjustors, as well as window regulator rollers, door hinge bushings, and seat track slides are growing applications in today's cars.

Nylon and acetal resins play an important part in the new "greased-for-life" steering linkage joints. Tetrafluoroethylene resin is also being used. Desirable frictional and wear characteristics, as well as ability to carry substantial loads, are required for this important application. A broadening of this application to suspension and body joints is predicted.

Seals for a 1961 model power-steering pump are made of tetrafluoroethylene resin. The pump operates at 750 psi and 350 F. Future applications of this temperature-resisting material are expected to include seals and piston rings for the transmission and seals for the engine as well.

Plastic housings for gears, fuel pumps, and carburetors are under active investigation. Corrosion resistance, good bearing properties, resistance to fuels and lubricants, and ability to design parts that can offer potential cost savings are factors favoring the use of plastics for such applications.

Future development of plastics for automobile applications will depend to a considerable extent on sound design, extensive development work on materials, and thorough testing by engineers. With today's widespread interest in plastics and availability of a much broader range of plastic materials, the number of plastic applications in U.S. automobiles is certain to grow rapidly, many material engineers believe.

SEALS among NSU

on rotating combustion

NSU reports substantial progress on seals as on spark plugs, cooling, fuel consumption

Based on paper by

Walter G. Froede

NSU Motorenwerke (Germany)

NSU's Wankel rotating combustion engine program has included extensive development work on the following phases:

- Seals.
- Spark plugs.
- Cooling.
- Fuel consumption.
- Overall durability of the engine.

EXTENSIVE DEVELOPMENT WORK has been carried out, both here and abroad, on the rotating combustion engine, since SAE Journal reported on Curtiss-Wright developments in June 1960.

The accompanying story summarizes recent activities of NSU in Germany on its versions of the engine.

Next month M. Bentele will discuss two Curtiss-Wright developments: a large displacement 780-hp rotary combustion engine using a single rotor, and also a 4-rotor engine.

Substantial progress has been made in all these areas, as reported herewith.

Seals

The Wankel layout has been designed to fulfill three basic requirements relating to seals:

- Low sliding velocities of sealing elements against the surrounding housing, even at high rpm.
- Continuous metal-to-metal contact between sealing elements and housing.
- The part carrying the sealing components must be shaped to permit cooling jackets close to seal grooves.

The sealing system elements are shown in Fig. 1. Note the radially movable apex seal blade, which is in a radial groove in the center plane through the apex. Close to both side walls, the radial inner portion is guided by axially movable interconnecting bolts. The end face sealing strips extending from apex to apex are in overlapping engagement with these bolts. All parts are preloaded toward the surrounding walls of the housing by wave springs. The main sealing force is produced by the gas pressure itself and, therefore, is variable during the relative movement of the rotor. The end face sealing elements are in contact with the side wall of the housing on a plane surface area, but the apex seals possess only a sealing line of contact. Fortunately, wear along this sealing line is extremely small, since the leaning angle between the plane of the apex seal and surrounding wall varies during the relative motion of the rotor. By the swinging movement of the apex seal, the line of contact travels around the seal

developments

engines

for Wankel engine, as well

and overall durability

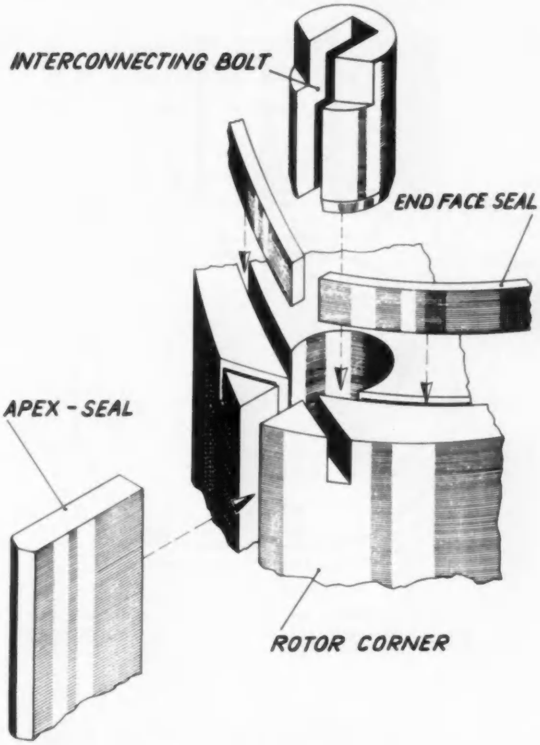


Fig. 1 — Components of sealing system.

top and the metallic contact is, to a certain extent, reduced by lubricant and gas wedge effect.

This design meets certain criticisms of the sealing system as follows:

- **Although there is only one sealing line of contact, its sealing ability is quite satisfactory.** Note that it has no gap except the required clearance within the fit of all components, as compared with the ring arrangement used in piston engines, which requires a gap, because of the difference in temperature expansion between piston and cylinder. Further, a worn piston ring inside a worn cylinder has an enlarged gap, whereas the continuous sealing line of contact along the rotor periphery stays tight, regardless of wear.

- **Total length of sealing line compares favorably with that of the piston engine, when the sealing line around the valve seats is added to that around the piston.** This is shown in Fig. 2, which compares sealing length for the two kinds of engine. Note also that, with larger leaning angles, that is, with more waisted shapes of the trochoid, the sealing length is reduced. With a leaning angle of 30 deg, the rotating engine has a sealing contact length only 65% more than that of the piston engine, and it is shorter when the length of sealing lines around the valve seats of the piston engine is included.

- **Sliding velocity of the apex seals along the trochoidal surface is reasonable.** The polar diagram around the trochoid (Fig. 3) shows that the sliding velocity at 5000 rpm stays within 29 and 67 fps, whereas the piston engine piston speed varies between zero and 57 fps. The leaning angle, in this

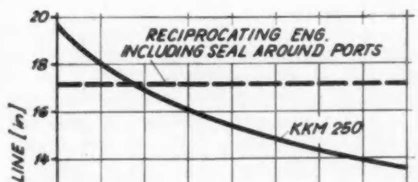


Fig. 2 — Length of sealing line for square piston engine and for NSU KKM 250 rotating combustion engine, for various leaning angles. (Both engines of 15.3 cu in. displacement.)

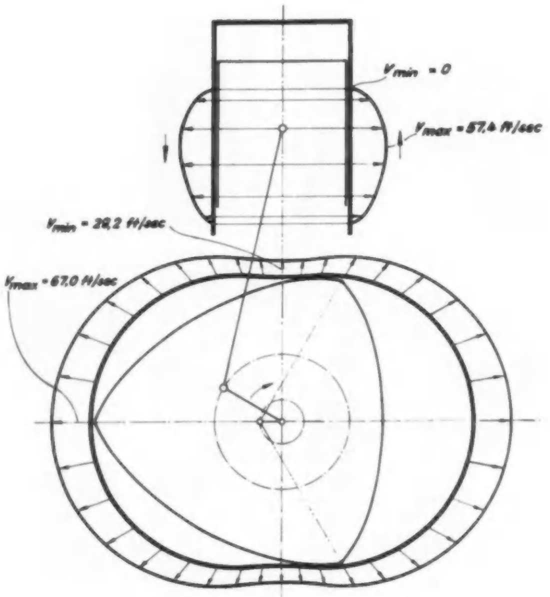


Fig. 3 — Sliding velocities for rotating combustion engine and reciprocating engine, at 5000 rpm. (Both engines of 15.3 cu in. displacement.)

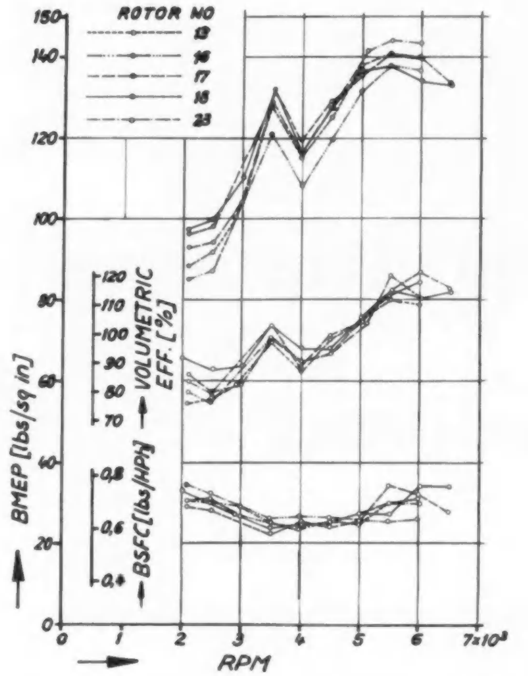


Fig. 4 — Performance data for test of five different rotors in same housing (KKM 250).

rotating combustion engines

. . . continued

case, is 23 deg, which is actually embodied in the NSU test engine KKM 250 (15.3 cu in displacement). The graph shows that the maximum sealing velocity of the apex seals is only 16% higher than that on the reciprocating counterpart.

Tolerances for the accuracy of the housing and for the fit of each sealing component inside the rotor are not yet settled. Fig. 4, which shows performance data for one engine into which five different rotors were mounted, indicates the requirements are not too high. The effect of this interchange on bmep, volumetric efficiency, and sfc is less than 5%, which seems tolerable. Tests with different center housings mounted in the same engine showed similar results.

The complete rotor shown in Fig. 5 demonstrates clearly that only the sealing line of contact is in metal-to-metal contact with the surrounding housing.

The oil scraper rings, which are located in both end faces of the rotor, have a loose fit in the corresponding recesses. Tightness between rotor and oil ring is obtained by plastic O-rings. This oil retaining method proved so tight that, even on 100-hr endurance tests, no measurable oil consumption from the sump could be observed.

Spark plugs

Tests with spark plugs in various locations indicate that, on rotors with a high compression ratio, a spark plug in the leading part of the combustion chamber is best, whereas medium and low compression ratios require a trailing location for the plug.

At present, the plug is being mounted in the peripheral wall in its center plane. In addition, NSU inserts the plug in a prechamber, which is connected to the combustion chamber with a 3-mm diameter flame hole. This reduces gas bypass from one chamber to another when the apex seal is sliding over the spark-plug hole. (Such a prechamber is not used on the Curtiss-Wright versions.)

On test engines giving high bmep, extremely cold plugs must be used, but plug life is still under 100 hr at full-throttle operation. It is anticipated, however, that the use of a condenser discharge or a low-voltage ignition system will greatly improve spark-plug life.

Cooling

The peripheral wall, as well as both end walls of the housing, include water jackets for the cooling liquid. The rotor is oil cooled, with oil fed through the hollow shaft and emerging through radial holes in the eccentric center plane. After passing the needle bearing that supports the rotor, it flows into the hollow interior of the rotor and is pumped out by a stationary scoop.

Both peripheral and end-wall intake ports were tested. Generally, the peripheral intake resulted in higher volumetric efficiencies, whereas side intake helped to reduce fuel consumption. The exhaust port was, in all cases, in the periphery of the center housing, with a generally radial direction.

Cooling water flow was kept to about 10 gpm, but an oil flow of 1 gpm proved sufficient for both lubrication and cooling.

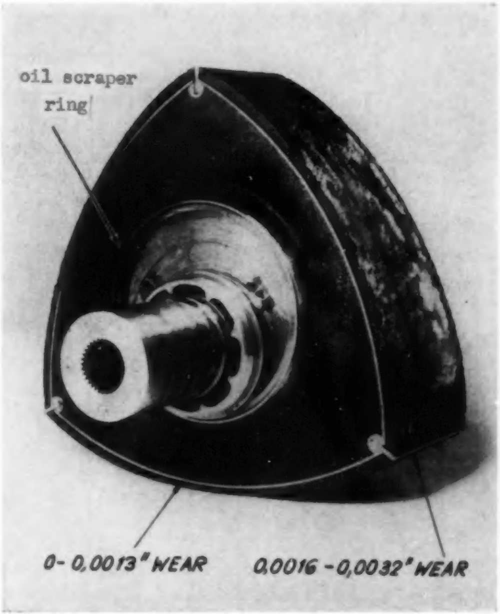


Fig. 5 — Photo of KKM 250 rotor (taken after 100-hr endurance run) shows that only the sealing line of contact is in metal-to-metal contact with surrounding housing. Gummy deposit visible in space between gas seals and oil seal is easily wiped off.

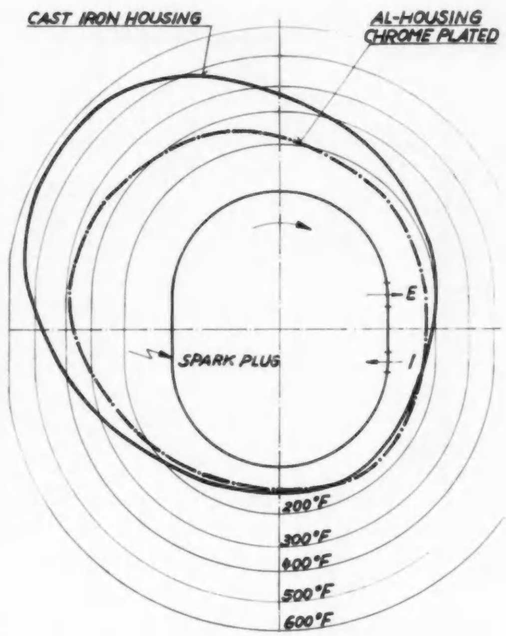


Fig. 6 — Temperature redistribution along periphery of housing, taken in center plane, 1 mm from surface (KKM 250).

Since it is vital that the center housing temperature be kept within close limits, this area was studied intensively. Fig. 6 is a plot of temperatures along the periphery of the trochoidal housing. Note that the maximum temperature was much lower with aluminum than with cast iron, although temperature distribution was similar. The maximum was at the point of both maximum pressure and maximum temperature. The 400 F maximum temperature obtained with the aluminum housing is low enough to give lubrication stability.

Fig. 7 shows that, compared with piston engines of similar mep, exhaust temperatures are high, indicating slow combustion, especially at high rpm. For instance, at 7000 rpm gas temperature was 1600 F. On the other hand, the heat transfer to the cooling water is considerably reduced at high rpm. Details of this relationship are plotted in Fig. 8. Heat transfer to water and oil are compared to the heat value of the engine output. If we rate the engine output at 100%, the heat transfer to the water is the same as the heat value of the power at 2500 rpm, but only 62% of this is transferred to the cooling water at 7000 rpm. Oil takes 25–30% of the effective power. Part of this may be energy wasted inside the rotor in shaking the enclosed liquid.

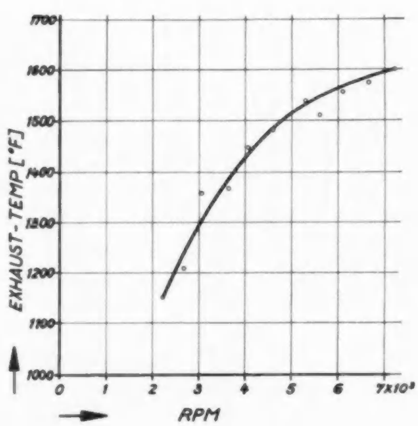


Fig. 7 — Exhaust temperature at full throttle (KKM 250).

Fuel consumption

Extensive fuel consumption tests were run with the KKM 250 engine, which was designed specifically for teststand operation (Fig. 9).

Minimum fuel consumption has not yet been obtained because variations in compression ratio, shape and location of combustion chamber, sparkplug arrangement, and fuel type must be investigated much more extensively to find the optimum combination.

Performance at part load and 5000 rpm is plotted in Fig. 10. Bmep was reduced from 150 psi to 10 psi. For a surprisingly wide range, fuel consumption stayed almost constant, which is unusual for a 4-stroke engine. Apparently, up to 80 psi bmep, combustion and sealing are about perfect, but at high bmep, leakage or slow combustion occurs, either of which might be responsible for the comparatively high fuel consumption.

A detailed study of pressure conditions inside a

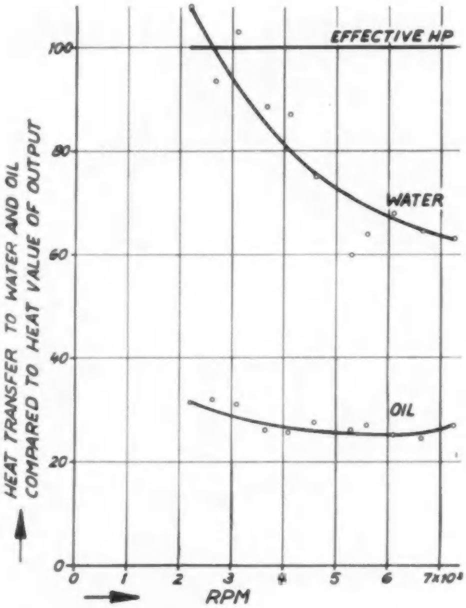


Fig. 8 — Heat distribution at full throttle (KKM 250).

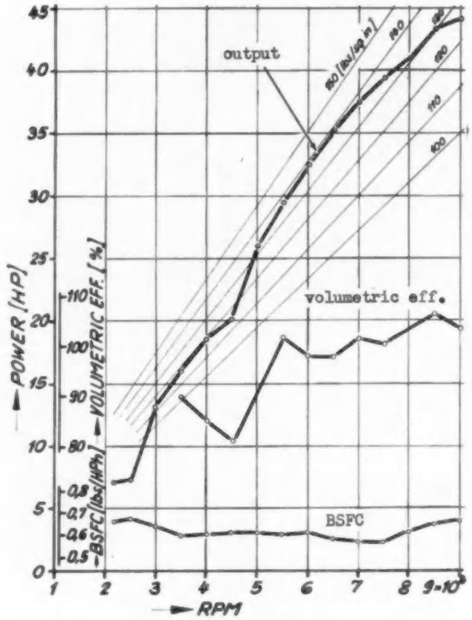


Fig. 9 — Teststand performance of KKM 250, without muffler.

Fig. 10 — Bsfc of KKM 250 at part load, 5500 rpm constant speed, peripheral intake of 22-mm diameter.

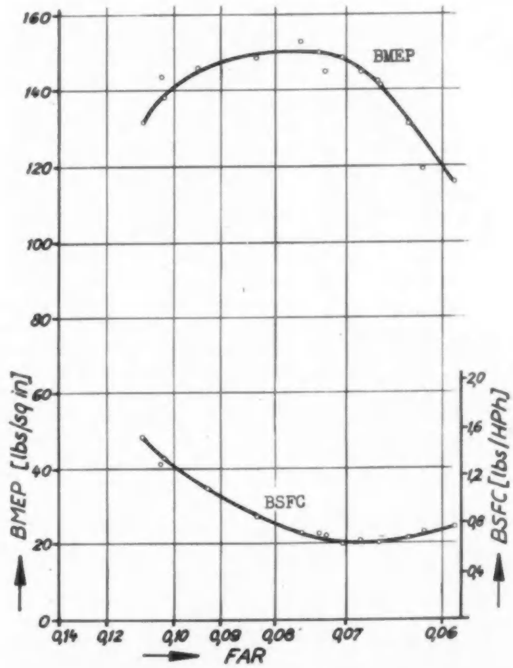


Fig. 11 — Bmep and bsfc versus fuel/air ratio for KKM 250.

rotating combustion engines

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rather low-powered rotating combustion engine showed that, for economic operation, speed limits are set on the low side by leakage and on the high side by slow combustion.

Fig. 11 shows the effect of fuel/air ratio on fuel consumption. The engine may be leaned out about the same way as a piston engine. Best fuel consumption, in this case, was at a ratio of 0.067, which is on the lean side for German commercial fuels.

The relationship between ignition timing and fuel consumption is shown in Fig. 12. The time of ignition must be considered differently from that on a piston engine because the intake, compression, expansion, and exhaust strokes each extend over 270 deg of shaft angle. This means that the time between ignition and tdc is 1.5 of the time in a piston engine that has the same spark advance. Thus, two scales are shown: one for actual ignition time as defined by the position of the eccentric shaft, and the other for the angle of a comparable piston engine.

Somewhat better fuel consumption figures were obtained with the KKM 400 (24.4 cu in.), which is a more advanced model, designed for possible installation in an automobile. Fig. 13 shows that the specific fuel consumption approaches the 0.5 line at high speed. Fig. 14 plots the mpg obtained for standard NSU Prinz automobiles in which KKM 400 and KKM 250 engines were installed, combined with a 4-speed transaxle of the Volkswagen type. A KKM 400 was also tested in the Sport Prinz. Fuel consumption was well below that obtained when these cars were powered by standard engines.

Durability

Fig. 15 shows bsfc, bmep, and power variations during the final period of a durability test carried out more than a year ago. The unit had an aluminum housing with a chrome-plated surface. Even at the end of the run, output and sfc were still improving. The only interruption was an occasional change of spark plug.

Results of another endurance test are shown in Fig. 16, with the KKM 250 running at 75–80% of maximum bmep. Speed was kept constant 5000 rpm. Operation at constant speed is very hard on the en-

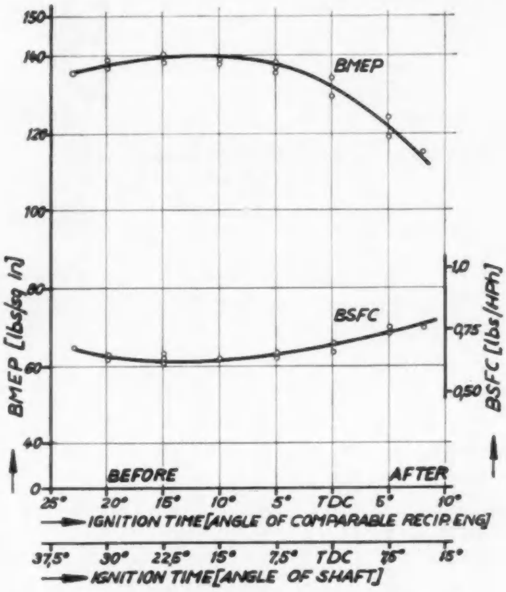


Fig. 12 — Effect of ignition timing on bmep and bsfc — 5500 rpm constant speed — for KKM 250.

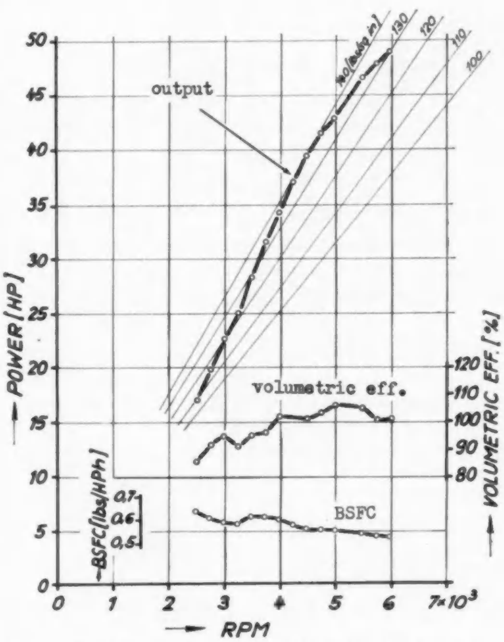


Fig 13 — Teststand performance of KKM 400, without muffler.

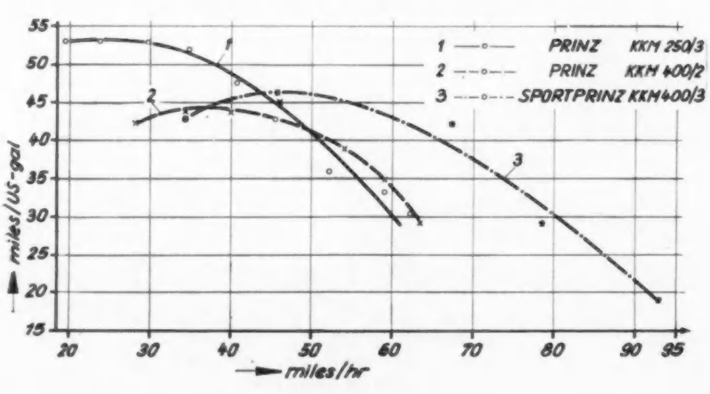


Fig. 14 — Road test mileage — average results on level road, both directions (preliminary results).

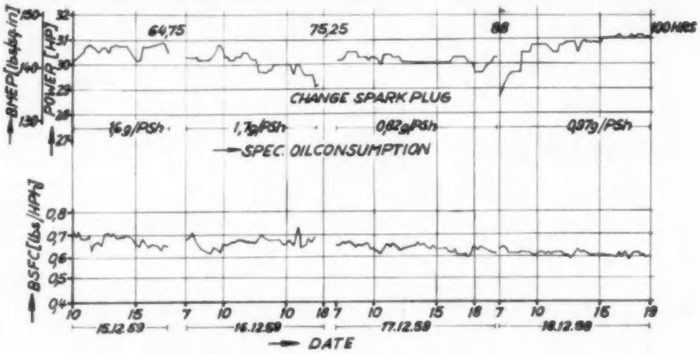


Fig. 15 — End of 100-hr endurance test, 5500 rpm, full throttle.

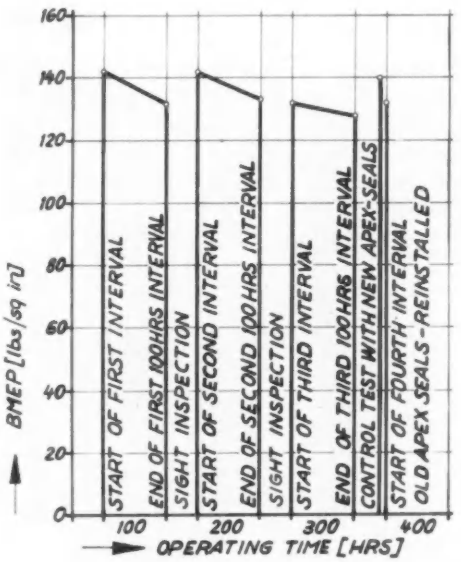


Fig. 16 — Loss of power during endurance run of KKM 250 (no parts exchanged), 5000 rpm, constant load of 102 psi.

Table 1 — Maximum Lifetime of Major Componnets
(deadline Oct. 29, 1960)

	Total Time, hr
Rotor	883
Apex Seals	410
Side Seals	883
Interconnecting Bolts	883
Oil Seal	883
Oil Scoop	883
Internal Tooth Gear	883
Center Housing	410
Side Housing Drive	668
Side Housing Antidrive	658
External Tooth Gear	658
Shaft	838
Flywheel	810
Bearing Rotor	657

rotating combustion engines

. . . continued

gine because the constant frequency of seal oscillations results in a tendency to generate chatter marks. Other engines, run in test cars, never showed distinct chatter marks, as they operated all over the speed and load range.

Output — as determined by full-throttle tests every 100 hr — gradually went down. After 300 hr, new apex seals of the original shape and material were installed. These brought back the original bmep to within 1%. After a short test, the wornout seals were reinstalled — and the endurance test is still going on.

Sealing component wear is shown in Fig. 17. Wear in the radial direction of the apex blade is not critical, considering the total dimension in this direction, which would permit far more wear without affecting sealing qualities. What actually causes the drop in power is wear at the end faces of the apex blade, which is more severe at the outer radial part, so that the seal changes from a rectangular shape to a trapezoidal shape. This effect can be avoided by a different design of apex seals.

Wear of end face seals and interconnection bolts is minute; the same applies to wear of oil scraper rings, Maximum life of all major parts, as tested to October 29, 1960, is given in Table 1. These data are preliminary, as the tests are still going on. A lifetime of 1000 hr for most of the parts seems well within the realm of possibility, especially as the best material choices have not been examined over longer periods.

To Order Paper No. 288A . . .
from which material for this article was drawn, see p. 6.

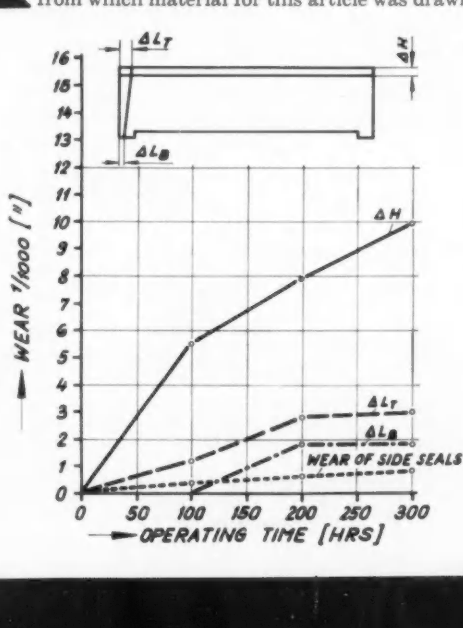


Fig. 17 — Wear of seal components during endurance run of KKM 250, 5000 rpm, constant load of 102 psi.

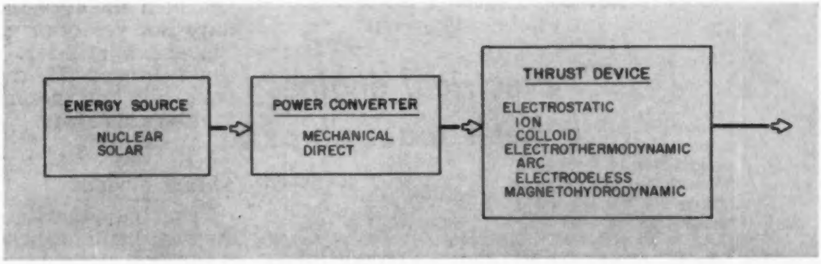


Fig. 1 — Basic subsystems of the electrical rocket. Nuclear or solar energy sources supply the power converter. The electrical output of the power converter operates the thrust device.

Electrical engines push space ships

Based on paper by

R. H. Boden
Rocketdyne

ELECTRICAL propulsion for space travel has the potential for significantly increasing allowable payloads. Table 1 compares the performance of the electrical device and a low thrust nuclear engine for trips to Mars and Jupiter. Although the flight time and payload capabilities are approximately the same for the Mars mission, the Jupitor flight shows the superiority of the electrical system.

The low thrust electrical engine takes over the job of propelling the vehicle after an initial earth orbit is established. During the midcourse trajectory period when the vehicle is being transferred from an earth orbit to an orbit about the destination, the electrical engine supplies the thrust.

The electrical engine is of the reaction type in which high-energy particles are discharged to generate thrust. The basic parts of the engine are shown in the diagram of Fig. 1. A source of energy is used to supply the input of the power converter, out of which electrical power is obtained. The electrical power is used to operate the thrust device.

Nuclear or solar sources best

Many types of energy sources have been studied, but the long mission durations encountered appear to narrow the choice to nuclear or solar sources. It is estimated that a moon mission would require 1800 hr of engine operation, assuming a thrust-to-weight ratio of 10^{-4}. Trips to Mars will be in the 8000–9000–hr range. Clearly, chemical sources are of no use here, despite all their advantages of simplicity, reliability, and low cost. The same holds true for the radioisotopes and the fuel cell type of device.

Nuclear or solar power are, therefore, essential to the development of any electrical propulsion system. The major difference between the two is in the amount and rate of energy they produce. A nuclear reactor can generate power at a very high rate, but the total amount is limited. The sun generates an unlimited amount of power, but at a relatively low

Table 1 — Comparison of iron and nuclear rockets.

Mission	Mars		Jupiter	
Rocket	Nuclear	Ion	Nuclear	Ion
Transfer Orbit	Elliptic	Elliptic	Elliptic	Parabolic
Characteristic Velocity, km/sec	7.5	7.5	17.5	74
Payload Fraction	0.36	0.36	0.10	0.20
Total Round Trip, Days	970	1100	2200	1100
Waiting Time at Target Planet, Days	450	450	210	10

Electrical engines push space ships

. . . continued

rate. In the earth's orbit it amounts to about 1 kw per 8 sq ft.

Solar and nuclear sources are both important. For thrust requirements up to 0.02 lb they are competitive; above this thrust the nuclear source seems best. To illustrate, data on the SNAP 2 reactor show it can probably generate a thrust-to-weight ratio of 5×10^{-5} with a thrust of 0.014 lb and a specific impulse of 10,000 sec. A similar analysis of a solar device indicates a thrust-to-weight ratio of 2.5×10^{-5}. At higher thrusts, in the range of 1 lb, engine size for the nuclear system would be some 10,000–20,000 lb lighter than the solar unit.

As for the mode of converting the power into the electrical form, the well-known mechanical systems still hold their ground. Turbine-driven generators have not yet been overtaken by the newer direct conversion systems. These devices, such as the thermionic diode, the magnetohydrodynamic systems, and the thermal electric systems are still in the research stage.

Thrust devices

Three classifications of thrust producing devices may be distinguished:

1. Electrostatic (which include the ion and colloid devices);
2. Electrothermal arc jet (which works on the principle of heating gas and then expanding it through a DeLaval nozzle to generate thrust precisely the same way that a chemical rocket does);
3. Magnetohydrodynamic type of engine, which accelerates the plasma by Lorentz forces.

Some ion thrust devices are now discussed. One type of ion thrust device is based on the arc source shown in Fig. 2. Bombardment of the vaporized propellant gas in the arc source forms a plasma. The ions are extracted from the plasma and accelerated through an electrode array. The electrons are collected and flow back to the power generator

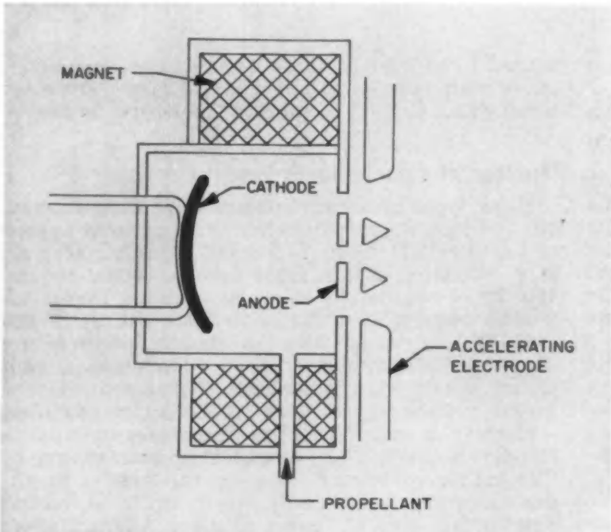


Fig. 2 — Arc-type source. The vaporized propellant gas in the arc source is bombarded by electrons, forming a plasma. The magnet collimates the bombarding electrons. To achieve thrust the ions are extracted from the plasma and accelerated through an electrode array.

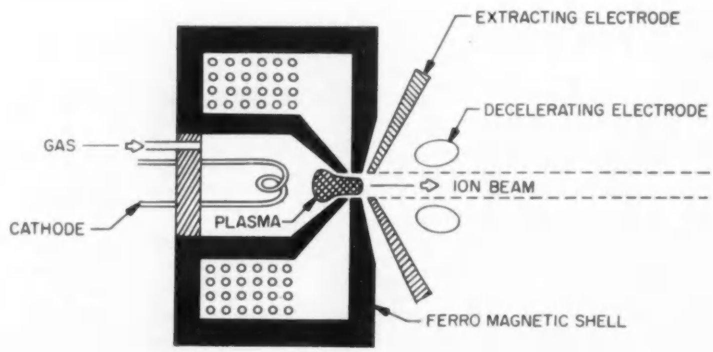


Fig. 3 — Von Ardenne ion source. An intense magnetic field is generated near the exit of the source. This field causes reflection of the electrons so that most of the energy is dissipated in ionizing the propellant gases. A high efficiency is achieved with this device.

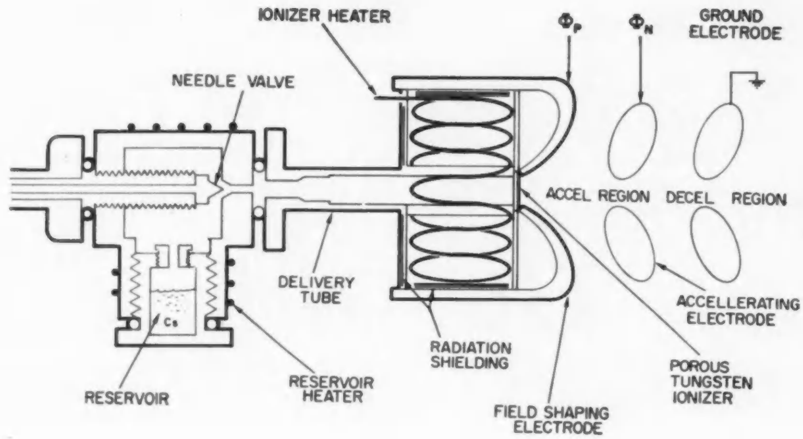


Fig. 4—Thrust chamber utilizing a surface contact source. Ionization takes place on the porous metal where the ions are evaporated. The ions are then accelerated through an electrode array to generate thrust.

to be re-emitted. The magnet is used to collimate the bombardment electrons of the arc.

Another kind of arc type source is the Von Ardenne source, developed in East Germany. It is shown in Fig. 3. One improvement effected by this device is the intense magnetic field generated near the exit of the source. This field forms a magnetic mirror which causes reflection of the electrons, so that most of the energy is dissipated in ionizing the propellant gases. In combination with the very high potential of the extracting electrodes, the device achieves a high efficiency. This type of engine will require a set of decelerating electrodes to obtain the specific impulse desired from this type of engine.

Another type of widely used source is a surface contact unit as shown in Fig. 4. The components of the engine using this source include the propellant supply, a control valve, a diffusion chamber, and a plate of porous metal through which the propellant flows. Ionization takes place on the porous metal; the ions are evaporated, escaping as a gas, and the electrons are collected. The ions are accelerated through an array of electrodes to generate thrust.

The colloidal system is basically an ion engine. Heavy particles are used for generating thrust. First the propellant must be dispersed into the proper size, a few microns in diameter. Then these particles are charged so that the proper charge-to-mass ratio can be obtained. The propellant can be a liquid or a solid.

Liquid propellants are first dispersed and then condensed into particles of the desired size. Electrostatic dispersal may also be used. Using a solid colloid requires that the propellant be ground to the proper uniformity and fineness. A great deal of power is required to do this. Charging of any of these particles can be obtained by electron bombardment, ion bombardment, and by surface contact. The methods used are similar to the methods used in obtaining atomic or molecular ions.

Power required

Fig. 5 compares the power required to operate the arc-type, and the surface-contact type of ion engine, for various accelerating voltages. For one pound of thrust the power supply must be capable of developing 400–500 hp. At low specific impulse the power required by the arc type engine is great. A minimum required power is reached as the specific impulse is increased, but after this minimum point the required power climbs. The surface contact unit will not require as much power in the low range because of higher efficiency. As all of these systems approach zero specific impulse the power requirement increases without limit.

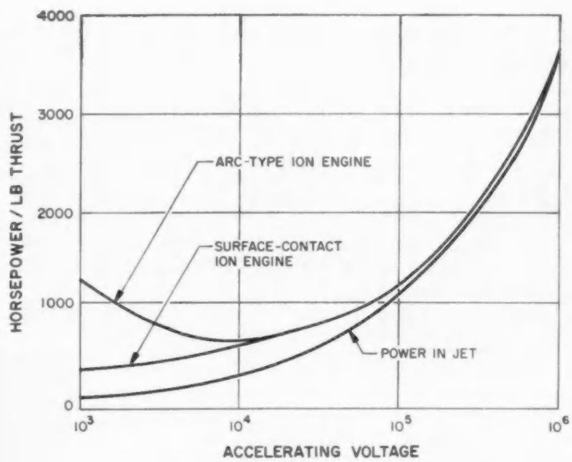


Fig. 5 — Power requirements of the ion engine. At low specific impulse the surface-contact engine requires less power than the arc-type engine. Power required by all systems increases without limit as the specific impulse aproaches zero.

(This article is based on part of an Astronautic Symposium developed jointly by SAE and the Air Force Office of Scientific Research. The Symposium is available only as a book, titled "Vistas in Astronautics — 1960." To order, turn to p. 6.

Go Karting!!

Based on talks by

R. G. Macadam, P. F. Quick, and W. K. McPherson

These three talks comprised a Panel Meeting organized and operated by the Junior Activity of SAE Detroit Section.

GO KARTING is a 4-year-old automotive sport, born of a car lover looking for excitement and some Army surplus stores . . . now worth $25,000,000 a year to its suppliers and billions in thrills to its participants on 4,000 specially designed tracks throughout the U. S.

It is a sporting boom which provides relatively safe racing for many automobile enthusiasts who never otherwise could have gotten into racing — because of both hazards and costs.

. . . And, incidentally, it is improving the acceptance of the 2-cycle engine in this country — and accelerating the need for continuous improvements in such engines, including greater specific output, higher speeds and greater endurance life.

How it got started

In the fall of 1956 the oppressive quiet of the Pasadena Rose Bowl parking lot was brought to an

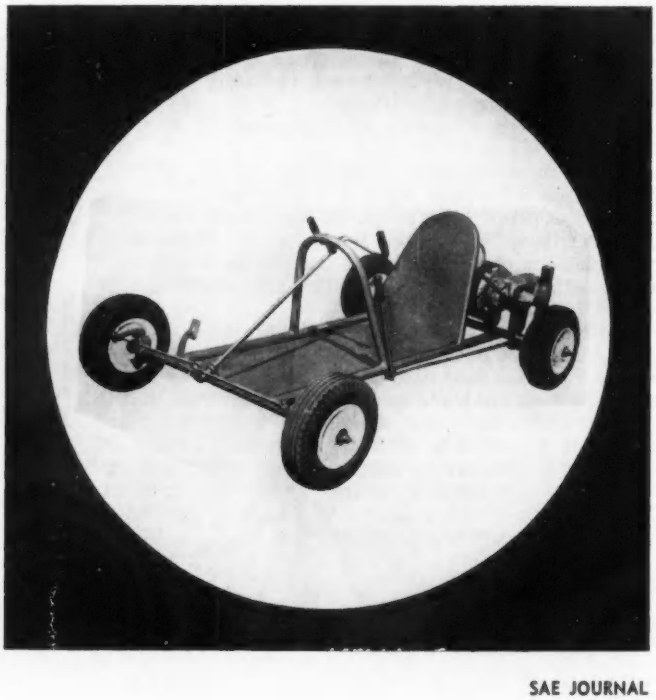


Fig. 1 — **First commercial kart** — circa 1957.

GO KARTING is a 4-year-old automotive sport

abrupt close by the raucous clatter of a West Bend 2-stroke engine.

A passer-by might have noticed the peculiarity of a full-size man moving across the surface at remarkable speed with no apparent effort, no apparent means of propulsion other than a tremendous quantity of noise, and the only apparent means of support being four ridiculously small wheels rolling merrily along beside him. The man was one Art Ingels, an employee at the Kurtis Car Works, in full possession of his sanity, a lover of cars — looking for excitement. Hidden beneath his generous bulk was a simple arrangement of pipes and rods that explained the way in which the wheels had followed him around the lot.

There was a small group of spectators at this historic event. A few probably laughed, but the more perceptive conned Art into giving them rides on the rig and the following week — lo and behold — just like rabbits.

Ingels had built himself a real kick-in-the-pants. It seemed that anyone who rode it was compelled to follow the pattern — through the surplus stores, to the welding shops, here a bit, there a bit, until — Voila! — Go Kart.

Shortly, liaison developed between a surplus dealer, who grabbed every 750 Model West Bend available, and a couple of avid car nuts, who copyrighted the name "Go Kart." Then with great ingenuity and much surplus material they marketed a complete car kit: frame, engine, wheels, tires . . . all for $129.95.

These first karts were crude, but they provided a sensation that will not easily be duplicated (See fig. 1). The unpadded seat was high, a full 5 in. off the ground, with no side rails to hold the driver in place. The wheels ran on ball bearings designed for industrial use, and soon developed a remarkable amount of wobble. The steering assembly was of the most casual sort, with no regard for bearing tolerance or correct geometry. The brake was connected to only one wheel. When the brake worked, the results were frantic. Consequently, many of our most experienced drivers owe their continuance in the sport to the fact that the brake lining was a 1 in. square of oil soaked leather, pressed against the greasy drive sprocket with as much force as one cared to waste.

The engine was a 2½ hp lawn mower unit that could suck in as much dirt as fuel; that could develop enough slop to rattle louder than it fired; that could spew out enough foul smelling, wonderfully polluted air to make a dog sick, and run, and run, and run.

From these beginnings, an industry of some proportion emerged on the American scene. The gross on the total business was reported by Wall Street to be $3 million in 1958, $12 million in 1959, and was estimated to exceed $24 million in 1960. The original partners, the three car nuts, now own a large plant in Azusa, Calif., with a $25,000 test track and produce approximately 1000 cars per month.

There are three other companies of nearly equal size, and many others manufacturing karts, accessories, and related equipment on a smaller scale. Dozens of different makes have been offered to the buying public; many have already dropped from sight, as in the early days of auto building. A large number of nationally known manufacturers now recognize the karting field and produce goods specifically designed for it. Such names as Bendix, Firestone, Goodyear, West Bend, Clinton, McCulloch, and Homelite are typical.

Organization

One of the first troubles that threatened the new sport was the appearance of home-built freaks using conventional auto parts, "I" beam frames, monstrous engines, and incorporating unbelievably poor design, construction, and handling. It was recognized almost immediately that there must be some sort of uniform regulation if the sport was to grow. So, in 1957 a group of 12 men, thoroughly experienced in sports car racing, gathered in Southern California and formed the Go Kart Club of America. Through many, many evening meetings, a set of specifications was established that still serves as the

Go Karting!!

. . . continued

vehicle code for almost every Go Kart club, manufacturer, and special building.

Through the work of this club it is now possible to run at any one of over 4000 specially designed race tracks in this country with no concern over whether or not your car will be acceptable. Full insurance protection is available to safety approved tracks through the U. S. Karting Association, and the American Kart Mfrs. Association has been formed to guarantee adherence to rigid standards of safety and reliability in construction. G. K.C. A. Regions have been recognized in such areas as Great Britain, Europe, South America, Australia, Canada, and Mexico.

Regulations

The regulations governing design and construction are quite all-encompassing, yet readily adhered to and easy to scrutinize at the technical committee desk. At each race meet the cars are checked to ascertain their compliance to the dimensional restructions on wheelbase (40 to 50 in.), tread (2/3 of wheelbase), overall length (less than 72 in.), tire diameter (9 to 12.75 in.), and overall height (26 in.). Following this, a visual check is made of all bearings, welds, steering, safety wiring, firewall provisions, fuel systems, exhaust, tires, and drive train, and the brakes and throttle are checked for function and adequacy. If approved, the kart is then classified for competition according to its total cylinder displacement, and the retail cost of the engine or engines.

1. Class A bushing	up to 5.8 cu in.	bushing bearing only
2. Class A standard	up to 5.8 cu in.	under $100 retail
3. Class A super	up to 5.8 cu in.	over $100 retail
4. Class B standard	5.81 to 11.6 cu in.	under $200 retail
5. Class B super	5.81 to 11.6 cu in.	over $200 retail
6. Class C standard	11.61 to 16.5 cu in.	under $250 retail
7. Class C super	11.61 to 16.5 cu in.	over $250 retail

A price ruling was put into effect in the winter of 1959. A majority of engines introduced since then sell for $99.95. Only engines of 2 stroke configuration are allowed, for reasons of simplicity, cost, ease of maintenance, and low weight. No form of transmission may be employed which would allow a change of drive ratios while in motion. Required driver safety equipment: crash helmet, goggles, gloves, and jacket are checked and must be used at all times on course.

Course

The Go Kart is best suited to a road-type course and its design evolution is directed at top performance on this type of track.

Much thought is given to the safety of competitors and spectators in the design of tracks, with certain minimum distances between opposing sections (40 ft), and between the track and spectator fence (35 ft). Straight sections are not to exceed 300 ft and must be followed by turns of not less than 10 ft radius for each 100 ft of preceding straightway. Karts are used on oval-type courses of dirt and asphalt, but they do not develop their full potential under such restrictions. On a good course, a potent large class machine can reach speeds of 60 to 70 mph, and yet average only slightly more than 35 mph per lap, coming out of the turns with wheels spinning, blue smoke trailing behind, and a racket that must be heard to be comprehended.

Driving

The driving of these bombs is as subtle a skill as that employed in any of motor racing's other forms. Problems are presented to the driver ranging from the niceties of a good start to the challenge of a full bore drift through a 40 ft radius bend, to 230 deg carousel, to driving turns on "line" and off line, in and through traffic (see Fig. 2).

Kart chassis

The design of the kart is comparable in many respects to the automobile chassis. In the case of the karts, the chassis, to a large extent, is the total vehicle.

The kart frame has several unique requirements. Since there are no exterior surfaces or bodies allowed, most kart builders give consideration to overall appearance and neatness of construction. Another factor, which in many cases is neglected, is seating and driver comfort. Because of the nature of the machine, and the type of tracks on which competitive events are run, the effort in the design to assure a kart that handles and performs satisfactorily can all be in vain if the driver is perched precariously on a lurching buckboard, and thus, cannot keep control of his vehicle.

The lack of a suspension, and the type of engine and drive line utilized, impart vibrational loads into the chassis frame, which if not allowed for, result in premature frame failures.

A typical kart frame is of ladder-type construction made from steel tubing welded together. Most karts are made of chrome molly steel (AISI 4130–4140) of 1 to 1¼ OD with a typical wall of 0.062 to 0.100. Due to concentrated loadings at the welded joints and the type of material used, heli arc welding is required. In addition, in most cases of specials, the completed frame assembly is heat treated. A typical ladder-type kart frame is shown in Fig. 3. The tubular side rails are generally depressed to bring the seat portion down to approximately 1½ to 2 in. of ground clearance.

The rear portion of the frame acts as a support for the rear axle and the engine mount, and carried forward gives some form of lateral restraint for the

Fig. 2 — **The GO KART is best suited to a road-type course** and its design evolution is directed at top performance on this type of track. (Shown is a Go Kart Club of America course at Fenton, Mich.)

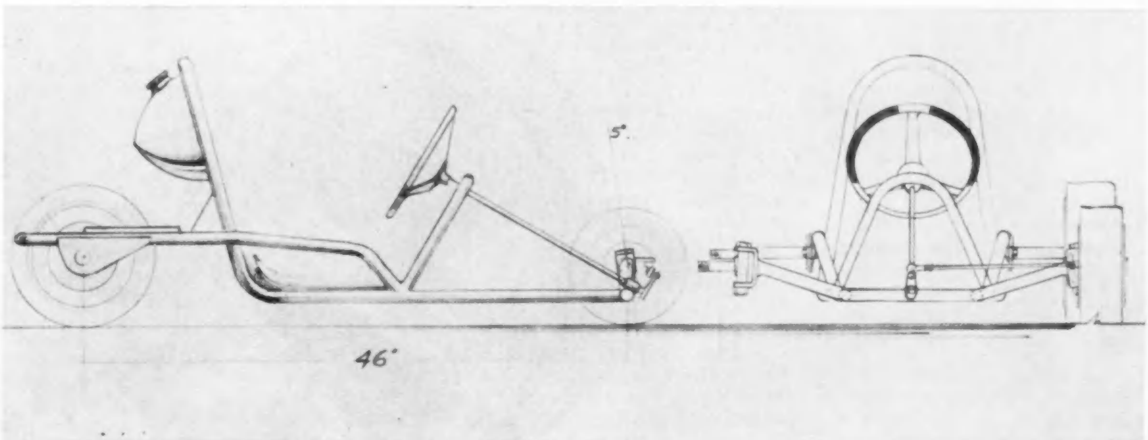


Fig. 3 — **A typical kart frame is of ladder-type construction** made from steel tubing welded together. In the typical frame shown here, tubular side rails are depressed to bring the seat portion down to approximately 1½ to 2 in. of ground clearance.

driver. The front axle is therefore required to kick up at the ends to support the spindles. This doubling up of the side rails at the point of maximum bending moment gives the required beam stiffness, yet allows the degree of torsional flexibility which is dictated by the lack of a suspension system.

Variations of this theme are not uncommon. Space frame, central torque tube, and fabricated sheet metal side rails have all been used with success. The weight factor must be considered in all components, and since the frame is one of the largest components, attention to details in saving weight pays off in increased performance.

Suspension and handling

As previously mentioned, the vast majority of karts are suspensionless vehicles. A kart is a com-

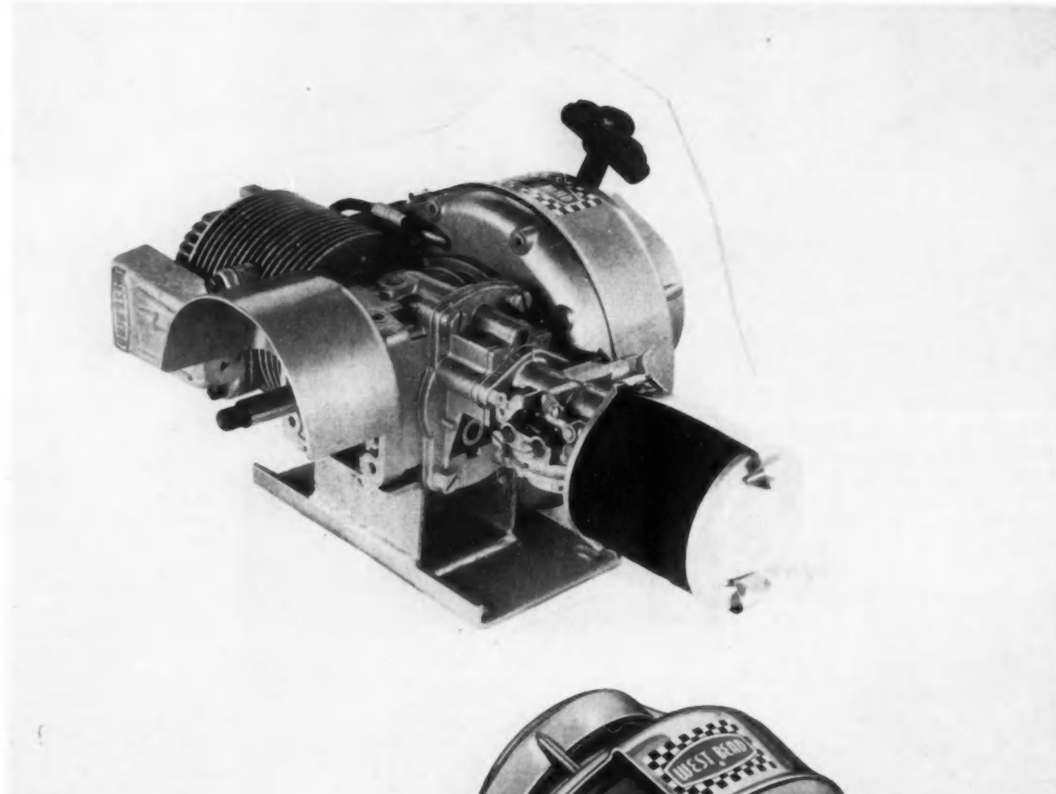


Fig. 4 — **(Top) Typical kart engine** with accessories. **(Bottom) Cut-away view** of typical kart 2-cycle engine.

petition car generally run on a paved track, in which the power to weight ratio is one of the major factors. To date, suspension development has not indicated that the advantages are worth the weight penalty.

Tires and wheels

Early karts utilized existing tires and rims which had been developed for scooters and similar applications. As the quantity became larger and racing was centering around the paved road-type courses, it was apparent that the lessons learned by their big brothers in the racing of automobiles could be used.

Retreaded knobby tires appeared in the form of "slicks" and are now available from most manufacturers as original equipment tires. The maximum tire size allowed is now 12.75 overall diameter and most karts utilize a 3.50–6 on the rear and either a 3.00–4 or 3.00–5 on the front.

Here again, the designer is faced with the problem of evaluating the advantages of the larger tires and the weight penalty which goes along with them. The early use of conventional pressed steel wheels with bronze bushings or unground ball bearings has been supplanted by cast magnesium or aluminum wheels and precision bearings.

Controls

The steering wheel on a kart serves the primary function of giving the driver something to hang on to and a secondary function of steering the vehicle. Lock to lock on a typical kart is about one-half a turn. The steering linkage could not be made much more functional. The shaft actuates a pitman arm which in turn is attached to the steering arm on the spindle by a link and in turn through another link to the other spindle. G.K.C.A. rules specify that all rod ends must have universal-type swivel joints and specify minimum physicals. All steering linkage and running gears must be safety cottered. Little attention was paid to proper steering geometry on the early designs; recently most karts have been laid out correctly.

The throttle and brake must be pedal operated. In many cases the location and design of the pedals have been such that it was difficult at best for the driver to keep his foot in position, particularly in cornering. Recent designs have finally recognized that a brake pedal cannot be of much value if it is not accessible to the driver's foot. Most brakes are acutated directly from the pedal by a tension rod or cable to the brake in the rear. The throttle control is also foot operated and connects to the engine by a bowden cable or a rod. In the case of a multiple engine installation, common practice is to have a cross shaft under the engine with individual bell cranks or a single bowden cable actuating an equalizer cable in the rear.

Brakes

Braking systems have varied from the simple paddle drag against the tire to hydraulically actuated spot discs. Speeds in excess of 65 mph in the short straights with a course average of 35 mph being typical, the brakes get quite a workout. Up to this time, I know of no successful installation of a four-wheel brake. As a locked rear axle is currently being used on almost all machines, a single brake in the rear effectively brakes both rear wheels. There is no clutch control on these karts, so the driver is braking against engine torque.

Kart engine

From a design standpoint on a single cylinder, air-cooled 2-cycle (see Fig. 4), there are three basic approaches:

(1) a combination crankcase and cylinder casting;
(2) a barrel-type crankcase with a separate cylinder casting mounted to it; and
(3) a split or two-piece crankcase design and a separate cylinder bolted to it.

There are advantages and disadvantages to each of these approaches.

Current West Bend models use the combination of cylinder and crankcase because it has definite production advantages. It is possible to machine the complete cylinder casting in a single progressive setup which serves to simplify the machining process as well as to insure perfect alignment of the various bores and faces. Cylinder castings are usually aluminum but the separate crankcases can be magnesium for even greater weight reduction.

Two-cycle engines may also be classified by their method of scavenging. The two common approaches are either loop scavenging (flat piston) or cross scavenging (deflector piston). With loop scavenging, the intake charge enters from two points and makes a full loop before exhaust.

In contrast to the loop engine, the cross scavenged engine with a deflector top piston directs the incoming charge upward into the combustion chamber. Normally better low end performance can be expected from this approach since the piston deflector directs the charge through its pattern at all speeds for complete scavenging.

Different types of induction systems have been utilized on 2-cycle engines, including a 3-point system, reed valves, poppet valves, and rotary valves. During the past few years, however, the reed valve has been most generally accepted.

Carburetion

Depending on the application, quite a few carburetor approaches are used on 2-cycle engines. These approaches vary from a self lift or suction carburetor, more commonly known as a mixing valve, to a more costly approach, the diaphragm carburetor. There are also side bowl and concentric bowl type carburetors used for different applications.

The diaphragm type carburetor found most acceptable for karting applications generally incorporates a diaphragm type fuel pump. The pump diaphragm is actuated by crankcase pulsations. This pump provides an adequate supply of fuel under the severe vibrations of kart operation.

To assure an adequate fuel supply without a pump, using gravity feed only, a sufficient fuel head is needed to overcome any bubbling in the fuel line. The diaphragm carburetor has a very small fuel

Go Karting!! ... continued

chamber so that fuel metering is constant in spite of the severe vibration and washing of fuel within the chamber on tight turns. This is probably its biggest advantage over some float type carburetors.

Engine modifications

The average 2-cycle engine, as we knew it 20 yr ago, operated at speeds of around 3000 rpm with an extremely smokey fuel mixture of possibly one pint of oil per gallon of gasoline, furnishing an output of perhaps ⅓ to ½ hp per cu in. In contrast, a present 5.8 cu in. engine is rated 5 hp at 6000 rpm; nearly 1 hp per cu in. It has anti-friction bearings throughout and weighs only 13 lb.

Many improvements originating in the field can eventually be incorporated in production engines. Some modifications, on the other hand, are not practical from a production standpoint, since they may offer only a small performance increase in contrast to the cost involved.

Ports: Because drilling port holes is the most practical production approach, round port holes are common in the majority of engines. Squaring the ports will allow for greater effective port opening and better breathing, particularly at high speeds. Also, beveling on the outside of each intake port will aid the flow of gases.

Polishing: Some owners in the field have taken great pains to polish all the internal passages in the engine. This complete polishing in itself, has only small, if any, merit, but the biggest advantage is gained in rounding or beveling any sharp passages to allow for smoother flow of the charge.

Reeds: Reeds are used effectively in 2-cycle engines because of their instantaneous response to a pressure differential. That is, on the upstroke of the piston, the pressure drop in the crankcase opens the reeds almost immediately. To aid in the opening, it is desirable to allow the reeds, when at rest, to stand 0.005 to 0.010 open so that the tension itself will aid in breaking the liquid seal around the seat of the reeds for faster opening. A reverse bend on the reed for positive seating will make the reed less responsive and can cause a power loss.

Carburetor venturi: On a kart, instantaneous acceleration is very important to bring the kart out of tight turns. This means that the venturi size must be limited so that standard production engines can be operated satisfactorily by the average driver. An experienced driver, however, can run with a "bored-out" or slightly oversize venturi by feathering the throttle in turns to maintain air velocity through the venturi, so that the nozzle continues to deliver fuel.

Fuels: Throughout the country, all types and mixtures of exotic fuels are being run including combinations with nitro methane, alcohol, ether, castor oil, and water. This is a field in itself. It is almost impossible to ever come up with the best fuel for everyone. For instance, some fuels are extremely effective with high compression engines but do little for some stock models. Because of many variables involved with fuels, it is not practical for a manufacturer to offer or specify fuels.

Ignition Timing: The average loop-scavenged engines operate with ignition timing in the range of 25 deg before top dead center. Cross scavenged engines fire at about 35 deg before top dead center. There are advantages in advancing or retarding the spark depending on the type of track you are running on, that is, the length of straight-aways and the number of sharp turns. Along with this, the gear ratio (which ultimately determines the operating speed of the engine) also dictates the optimum ignition timing. On a fast oval track, an advanced spark will help the "top end" but that same timing on a tight road course will hurt acceleration or even develop preignition.

Crankcase Pressures: "Stuffing" the crankcase does help the engine output because it increases the crankcase pressures to provide better cylinder charging. It is accomplished by adding blocks to the reed plate, filling in void areas in the crankcase, and possibly even packing the inside of the piston. Stuffing very small areas, however, is not necessary because the performance gain is negligible.

Compression: Kart engines in the field are running with compression pressures varying from 100 psi to 200 psi. Increasing compression sometimes results in the need for varying the port timing. Therefore, increasing the compression alone, in some cases, may do nothing more than cause a heat problem. Higher compressions, however, do respond more readily to "fuels."

Spark Plugs: Standard production engines are usually furnished with the hottest plug possible to minimize spark plug fouling. Any changes in ignition timing or the engine output may result in the need for a colder spark plug.

Ignition: Standard production engines are provided with flywheel type magnetos having ignition output of 15 to 20 kv to meet the engine starting requirements. Some people have, however, increased their compression to the point where the ignition system is no longer adequate and therefore have had to resort to the use of an automotive type coil, condenser, and battery ignition for dependable starting and high speed operation.

It is impossible to define the percentage of increase in power that can be expected from any one engine modification. Also, no specific sequence can be outlined for modifying an engine. It depends completely on the combination with which a modification is run.

Drive and gearing

Now, in karting, many different automatic centrifugal clutches are available for all standard models of engines and are used most commonly. Clutches do have an advantage. They simplify starting of the engine. In uncontrolled slides or spins, the engines will continue to run whereas without a clutch, the engines might stall, putting the operator out of the race.

Originally karts were made with a "dead axle," that is, each wheel driving separately. This resulted in the inner wheel losing traction and spinning free on sharp corners. Most current models now have a "live axle" with both wheels locked to the axle so that if one wheel leaves the ground, all the power is transmitted through the wheel having the traction.

Problems and solutions in

Designing Caterpillar Compact Diesels

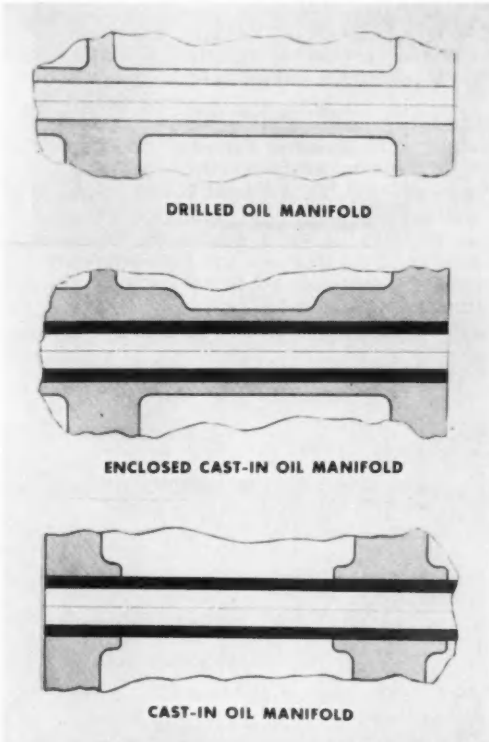


Fig. 1 — Iron was originally cast around the steel tube oil manifold in the cylinder head at junction points where holes were to be drilled. Current design calls for encasing the entire tube in cast iron. New drilling techniques may usher in a drilled oil manifold.

Based on paper by

D. W. Knopf, M. B. Morgan, and F. P. Buttke

Caterpillar Tractor Co.

IN DEVELOPING its family of three compact diesel engines for general-purpose use, Caterpillar made several departures from former design practice. Being a new design rather than a redesign, a number of problems were met and the more important ones are described here together with the solutions reached.

Cast-in oil manifold

The cylinder block was designed with a cast-in steel oil manifold, which took oil from the filters and distributed it the length of the block to bearings and other pressure-lubricated parts. For the prove design engines, iron was cast around the steel tube at junction points where holes were to be drilled. However, trouble was experienced with burning or melting of the steel manifold because the melting point dropped sharply as the carbon content increased with a transfer to the cast iron; the tube tended to bow between the points of anchorage, and fins of cast iron formed at the core junctions.

A solution to this problem was obtained by encasing the entire steel tube in cast iron, as shown in Fig. 1. A drilled manifold is now being considered because new drilling techniques are available.

Crankshaft oil seal

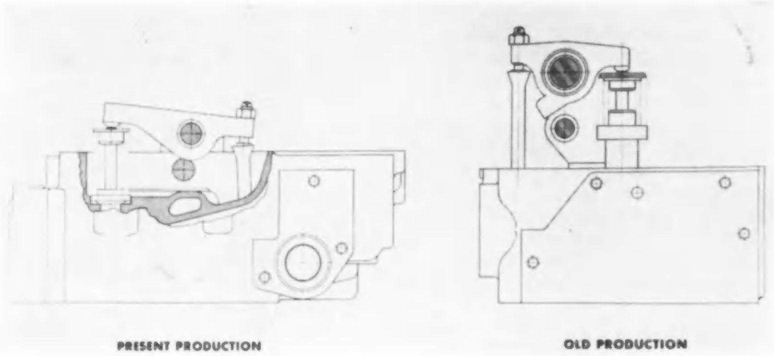
The oil seal on the rear of the crankshaft presented a hard problem from the very first engine. The seal was designed on the outside diameter of the crank flange to keep the engine length to a minimum. Because of the diameter and the cost factor, the first seal was a butt-joint piston ring. This leaked excessively and no revisions were successful. The problem was solved on the production engine by using a lip-type, spring-loaded silicone rubber seal.

Cylinder head design

The former production cylinder head was milled flat across the top (Fig. 2). The tall and flexible brackets holding the rocker-arm shaft were a disadvantage and so was the very narrow gasket between the valve cover and the top of the cylinder head made necessary by the close clearance between the valve springs on the inside and the precombustion chambers on the outside. Oil leakage through this gasket on the prove design engines was troublesome.

Solution to this problem began with designing a "bathtub" head (Fig. 2). This has a raised cast rim

Fig. 2 — Change from flat-top to "bathtub" cylinder head stopped oil leakage, permitted use of simple steel blocks for rocker-shaft brackets and shortening of valves and valve push-rods.



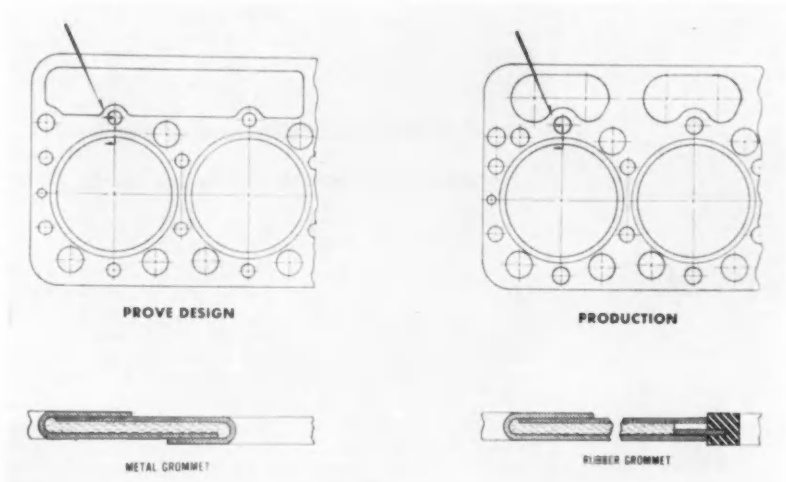
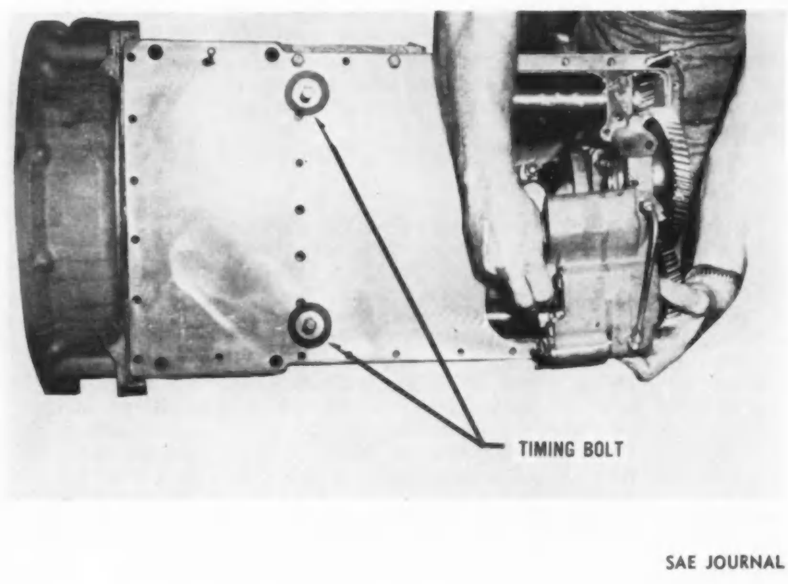


Fig. 3 — Oil leakage around cylinder head rear stud was checked by switch from metal grommet in gasket to rubber grommet molded to a steel washer, which is locked into the rest of gasket.

Fig. 4 — Bolt through oil pan into hole in balancer shaft prevents shaft from getting out of timing with engine when oil pump is removed without removing front cover.



on top of the cylinder head and a cored out center portion. The effect was to raise the valve-cover gasket surface above the oil level on top of the cylinder head, and eliminate the oil leakage by reducing the amounts of oil lying on the gasket and to provide a wider gasket to seal the oil better.

This design allows the rocker-shaft brackets to be made of simple steel blocks, and permits the valves and valve push-rods to be shortened 1.5–2.0 in., which lowers the top of the engine by that amount. The top of the head can now be oiled with internal drilled passageways instead of tubes. The principal disadvantage of the design is the necessity to machine the inside of the "bathtub" instead of slab-mill.

Cylinder head gasket

The production-version engine cylinder head gasket is a conventional type made from cooled-rolled sheet steel with an asbestos millboard center and copper grommets around the cylinder bores and water holes. There is an oil passage from the cylinder block through the gasket into the cylinder head around the rear stud. The 30-psi oil fed to the cylinder head created a sealing problem on the prove design engines, but tests showed the leakage could be stopped by using a rubber grommet. A rubber grommet on the production engines is molded to a steel washer, which is locked into the rest of the gasket as shown in Fig. 3.

Oil pump balancer shaft

Another problem was revealed when disassembling the 4-cyl prove design engine on which the oil pump is driven from the balancer shaft. When the oil pump was removed without removing the front cover — as would be done for inspection of main and connecting rod bearings — the balancer gears were free to rotate and the balancer shaft became out of time with the engine. The timing problem was complicated still further by the limited space for the oil pump. The pump had to be rolled into place because of alignment dowels on each side of the cylinder block and helical gears on the front gear train.

Here, the solution was to put a timing bolt (oil pan bolt) through the oil pan plate into an oversized hole in the balancer shaft to hold the balancers in correct timing to No. 1 piston (Fig. 4). The hole allows the shaft to rotate sufficiently to permit the oil pump to be rolled into place. Furthermore, the balancer timing bolts are so placed that it is impossible to install the oil pan in position until they have been removed.

Oil pump bypass valve

The prove design oil pump included a leaf-spring bypass valve set to relieve at 75–90 psi on the pressure side of the pump. It looked simple and inexpensive to make and it promised to end such troubles with the standard plunger bypass as cocking and sticking of the plunger, and fretting of the plunger in the pump body. (Fig. 5).

Under test, the bypass acted as a variable orifice always bypassing oil on a new engine. Moreover, it was discovered quickly the the number of leaf springs used, the curvature of the springs, the thickness of the sealing plate, and the flatness and squareness of the pump body in relation to the orifice hole were all critical items. They could be controlled in the laboratory, but only at excessive cost in production, and so the production engine has the plunger-type bypass valve with its known problems.

Cure for slobbering

One perplexing problem was slobbering — a condition whereby a spray, droplets, or a cloud of lube oil and/or fuel drips out of the exhaust system joints, or is blown out the exhaust stack, to smear everything it lands on. Slobber can come from three sources:

1. Poor piston and ring oil control.
2. Poor valve guide oil control.
3. An improperly designed fuel system.

Attention to pistons, rings, and cylinder liners minimized slobber from that area. Valve-stem-to-valve-guide clearance was made 0.0035–0.0055 in. to reduce the flow of oil down the valve stem without causing stem scuffing. And to control oil at the top of the valve guides, a valve-stem teflon oil seal is used on industrial engines. Other aids were modification of the idle groove and reduction of fuel-valve tip volume, the latter eliminating a situation in which fuel was not injected when the rack opened after engine deceleration.

To Order Paper No. 254A . . .
from which material for this article was drawn, see p. 6.

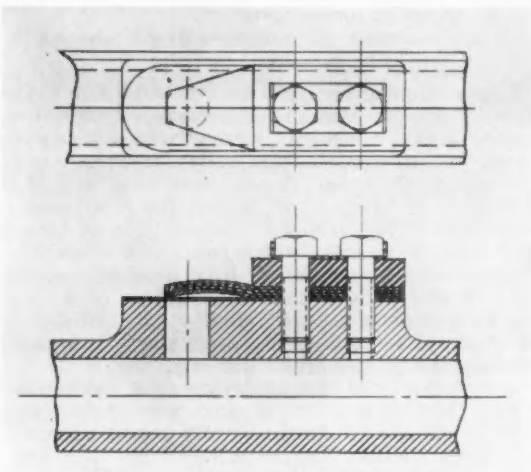


Fig. 5 — Leaf-spring bypass valve on oil pump promised simplicity and low cost but proved impractical in production because of many factors requiring close control.

Material drawn from an
SAE Metropolitan Section Paper

How Lincoln engineers solved

2 New "feasibility problems"

. . . generated by a "24 months or 24,000 miles" warranty. The problems: Is it practical to break-in engines at the factory? Is a 6,000-mile oil-change cycle feasible?

Based on paper by

Joseph M. Stout

Ford Motor Co.

LINCOLN ENGINEERS had to solve two basic problems in designing their 1961 Continentals to make feasible a new warranty covering "24 months or 24,000 miles — whichever comes first."

The problems:

1. The engine had to be broken in at the point of manufacture.
2. Feasibility of a 6000-mile oil change had to be proved.

Elimination of the 1000 and/or 2000-mile inspection by the dealer made it necessary to break the engine in at the factory. A "raw" new engine before break-in is impossible to adjust for idle mixture and idle speed. Moreover, as the rings wear in and the compression rises and stabilizes, the idle speed increases by 75 to 100 rpm . . . resulting in an increase in transmission creep which cannot be tolerated.

To accomplish this break-in at point of manfuacture, it was decided that a maximum of 3 hr per engine could be used to break it in, utilizing the available 48 test stands at Ford's Lima, Ohio engine plant, working two shifts per day.

A practical hot test procedure was developed in which "raw" production engines were broken-in for 3 hr by different methods — with periodic measurements of friction torque taken. The objective of effecting the break-in without too much increase in idle speed was met by this procedure — with plenty to spare. Many of the tested engines gained less than 25 rpm in 6000 miles, and none exceeded the 50 rpm bogie.

The Hot Test Procedure

This hot test procedure as finally worked out is as follows:

1. (a) Use SAE 20 oil.
   (b) Use slave spark plug wires, or install new wires after hot test.
   (c) Engine coolant supply — 160 F minimum, 170 F preferred.
   (d) Drive the engine water pump during hot test, main thermostat omitted.
   (e) Engine coolant temperature rise — 15 F maximum.
   (f) Power steering oil — 200 F maximum.
2. Fifteen minutes; 1200–1500 rpm no load; without rocker covers.
   (a) Examine rocker arm lubrication and all visible function items in this area.
   (b) Set spark.
   (c) Inspect for leaks, general engine functioning, and other items as included in 1960 model hot test running.
   (d) Balance the engine.
   (e) Install the rocker covers.
3. Thirty minutes; 2000 rpm; no load.
4. Two hours and fifteen minutes; 3400 rpm; no load.

5. About five minutes; check engine through speed range, from idle to 3400 rpm.
   (a) Operate each engine remote from other running engines and noisy machinery.
   (b) Verify the engine for noise, leaks, smoothness, etc.
   (c) Reset spark, with vacuum line disconnected, rpm (below the centrifugal advance limits) as shown in specifications for hot test spark setting.
   (d) Reset idle rpm to approximately 700.

Post Hot Test Procedure

1. Remove oil pan.
   (a) Examine oil pan sediment.
   (b) Examine cylinder bores, cam lobes, and other visible items in the crankcase area; turn crankshaft, as required, to complete the inspection.
   (c) Verify torque on main bearing cap bolts and connecting-rod nuts.
   (d) Re-install a clean oil pan with a new gasket.
2. Retorque all external gasket flanges.
3. Install a new service size oil filter. Refill with new customer-type oil of the proper seasonal viscosity.

ALL A DEALER has to do before delivering a 1961 Lincoln Continental is to wash it, says Ford's Joseph M. Stout from whose recent "A New Concept of Powerplant Reliability" was drawn material for this article.

A new warranty covering "24 months or 24,000 miles — whichever comes first" has demanded a new concept of reliability which provides that "all necessary adjustments and inspections are performed at the assembly plant, following a thorough road test prior to shipment to the dealer."

In his full presentation, Stout details the test procedures developed to implement this new warranty. He gives facts and figures with which other engineers can make their own analyses. To order this Paper No. S272 . . . turn to p. 6.

6000 Mile Oil Change Test

To devise tests insuring feasibility of the projected 6000-mile oil change cycle was a major challenge. They must simulate all the different patterns of driver behavior and car usage.

In developing such tests, Lincoln engineers built six test cars, which contained "trouble-free" items in the transmission, rear axles, electrical, body, brake, and suspension assemblies. (The items had been established as "trouble-free" following establishment and application of the break-in tests.)

The first series of experimental engines with the 3-hr break-in were supplied. Specialized calibrated carburetors which had been "flowed" were used. These cars were each driven 12,000 miles at Ford's Michigan Proving Grounds, cross country, and at the Arizona Proving Grounds . . . with service cycles of 6000 and 12,000 miles.

Five brands of "most severe" (MS) service oils were used throughout the tests. (These oils had been certified by their makers to meet the sequence tests recommended by Section G-IV of ASTM's Technical Committee D-2. Also, they had been approved by the Ford Fuels and Lubricants Group. . . . The sixth car — used for reference — was operated on an ordinary SAE 20 oil.

The feasibility of a 6000-mile oil change was established by the tests made with this equipment . . . and has been reaffirmed by hundreds of thousands of additional engineering test miles which followed.

Teardown examination of all six engines used in these test (completed in January 1961), revealed no distress . . . although the reference car engine could be identified by a slight accumulation of varnish which was not present on the other five cars.

A typical 6000-mile service and inspection report on engine items was produced by our car No. 19T935, as follows:

1. Drained engine oil (7.14 lb) and collected oil sample.
2. Removed oil filter and prepared same for analysis at Dearborn.
3. Cleaned crankcase breather cap.
4. Cleaned carburetor air cleaner element.
5. Checked gap on spark plugs — all gaps within specifications.
6. Checked power steering pump and reservoir for leaks. Oil leakage noted from cover and inlet and outlet fittings — cover and hose clamps retorqued.
7. Checked all external fittings and covers on engine for oil leaks.
   (a) Oil seepage noted at rear of valve push-rod cover. Front and rear bolts checked for torque — one rear bolt had zero torque, the rest were within specifications.
8. Checked belt tension. Water pump and generator belt tension 15 units, air conditioning belt tension 15 units, retensioned air conditioning belt to 19 units.
9. Checked distributor timing (vacuum line dis-

2 New "feasibility problems"

. . . continued

connected) and point dwell. Distributor timing 5 deg btdc and dwell 32 deg — reset dwell to 28 deg and timing to 6 deg btdc.

10. Distributor points normal.
11. Checked idle speed and quality of idle.
    (a) Idle rough.
    (b) Idle speed 519 rpm in drive.
    (c) Reset idle mixture ½ turn rich on left side.
    (d) Fast idle 720 rpm — reset to 650 in drive.
    (e) Reset fast idle to 650 rpm on first step of cam in drive.
12. Checked automatic choke operation — choke appears to be coming on too soon, resulting in poor hot starts at times. Otherwise, choke operation normal.
13. Checked throttle linkage — throttle linkage operation normal.

Type of Customer Usage — From available data it was possible to predict the car usage and divide it into four groups:

Group A — A small minority are driven 20,000–30,000 miles in two years on poor roads, at high speeds, under severe temperature and climatic conditions and with maintenance schedules inadequately observed.

Group B — A small minority are driven 3000–5000 miles in two years (mostly city driving) at low speeds over good roads and following recommended maintenance schedules.

Group C — A minority are driven 20,000–30,000 miles in two years under operating conditions and over roads which are similar to Romeo durability testing.

Group D — A larger majority are driven from 15,000–30,000 miles in two years at posted speeds and over moderately good roads but with inadequate maintenance schedules. (Skip completely or stretch beyond recommendations).

It is recognized that the car used by Group B is subjected to maximum corrosion damage. To simulate this condition, an accelerated test which immediately was nicknamed "The Old Maid" test was devised. Assumptions for this test were: —

1. The customer drives only 10 miles on the average of every other day.
2. Perhaps a trip of 1500 miles is driven twice in a two year period.

Projected: these assumptions indicated a warm-up and cool down frequency of 168 cycles per year, or a total of 336 cycles in two years, or 420 cycles in 2½ years. The accelerated test was planned to provide three cycles per day, which made possible its completion in seven months. The following daily schedule was maintained:

Time	Phase	Description
8:30[a]– 9:30 a.m.	A	Fill gas tank to ½ — start — drive 10 miles. Run at 30 mph and stop each ½ mile during the first five miles for 10 sec and accelerate at 8 in. manifold vacuum to 30 mph. The balance of the 10 miles to be completed at 30 mph nonstop (indicated).
9:30 –11:30 a.m.	B	Cold room soak at 5 F for cool down of engine oil to outdoor ambient temperature.
11:30 –11:45 a.m.	C	One lap run around track at 35 mph and return to cold room.
11:45 – 1:30 p.m.	B	Repeat phase B in cold room.
1:30[b]– 2:30[c] p.m.	A	Repeat phase A except at the end of the 10 miles make one wide-open-throttle start to 60 mph.
3:00 p.m.– 8:30 a.m.	D	Normal outdoor cooldown at ambient temperatures.

[a] One salt bath run at 8:30 a.m. on Monday, Wednesday and Friday for the months of November, 1959 through February, 1960.

[b] One mud bath run at 1:30 p.m. on Monday, Wednesday and Friday for the entire seven months.

[c] Car wash at 2:30 p.m. on Monday, Wednesday and Friday for the entire seven months.

Four 1960 Lincoln sedans were used in these tests. "Trouble free" and "long life" items were substituted for standard production parts throughout the car. Series I engines were furnished with special attention to sealing improvements, anticorrosion parts, and early 1961 carburetors with anticorrosion linkages. Three different name-brand MS certified oils were used together, with an SAE 20 oil used in the fourth car for reference. The tests were kept on schedule, with weekly reports on troubles and adjustments. The daily tests were completed on May 21, 1960 after completing 475, 481, 474, and 488 cycles, respectively. Two of the cars were checked for hot start to evaulate a late change in calibration specification and cold starts. The hot starts and the cold starts at 0 F were excellent. However, the cold starts at -27 F failed, due to choke linkage corrosion.

The cars were completely disassembled and displayed. Thorough examination of the engine interiors by our lubrication groups (both basic engine and research) revealed a minimum of sludge and varnish in the three engines using certified sequence test MS oil. There was little to choose between the three name brands tested. I feel certain you will not be disappointed when I report that the engine using regular SAE 20 oil was a "mess." Heavy carbon and sludge formation was accompanied by the expected varnish.

To Order Paper No. S272 . . .
from which material for this article was drawn, see p. 6.

Northrop outlines how

Data processing mechanizes aircraft production and cost control

Based on panel report by **E. C. YATES** Norair Div.-Northrop

Problems in aircraft cost control

DETAIL PRODUCT DATA are not normally available at the time of bid proposal. (Drawings have not been made, new concepts checked out, or new materials tested.)

"STATE-OF-THE-ART" is subject to high rate of technological change. Policy of delivering the product to most current capability means that design, manufacturing methods, and materials specifications are in a constant state of flux. Trend has been to increased complexity in each of these areas requiring more highly skilled personnel.

SCHEDULED ADHERENCE demands simultaneous activity in design, tooling, and production.

THE HIGH QUALITY of component detail parts, combined with relatively low quantity of production units precludes the application of conventional control systems.

See pages 74-77

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.)

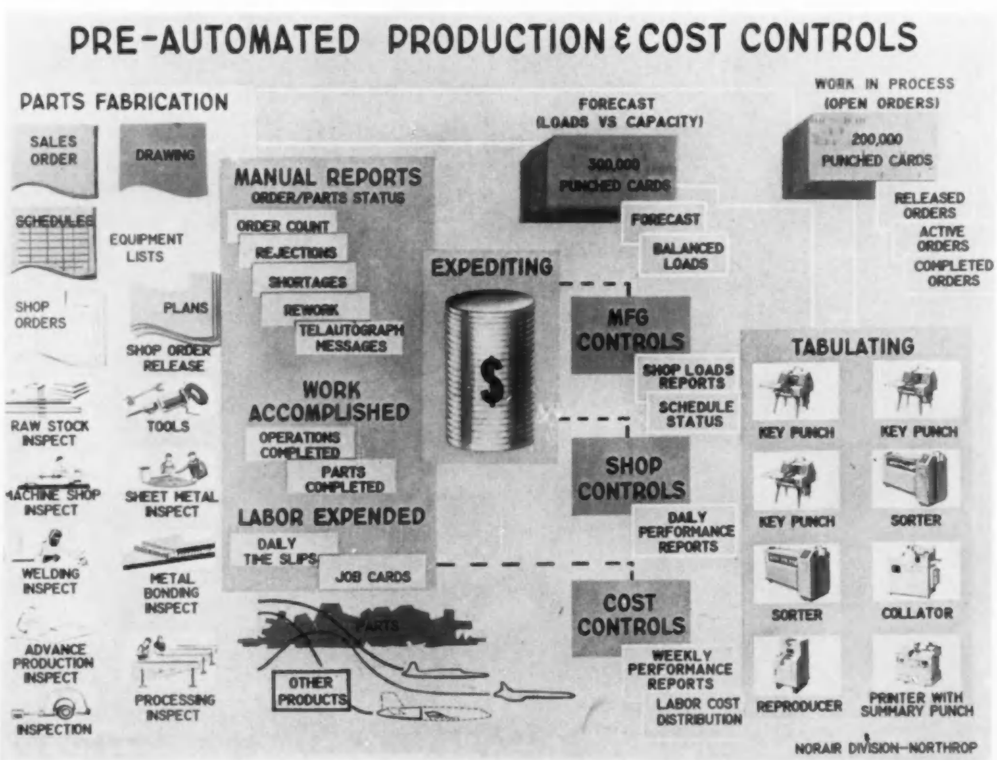
Objectives of the Northrop integrated cost control system

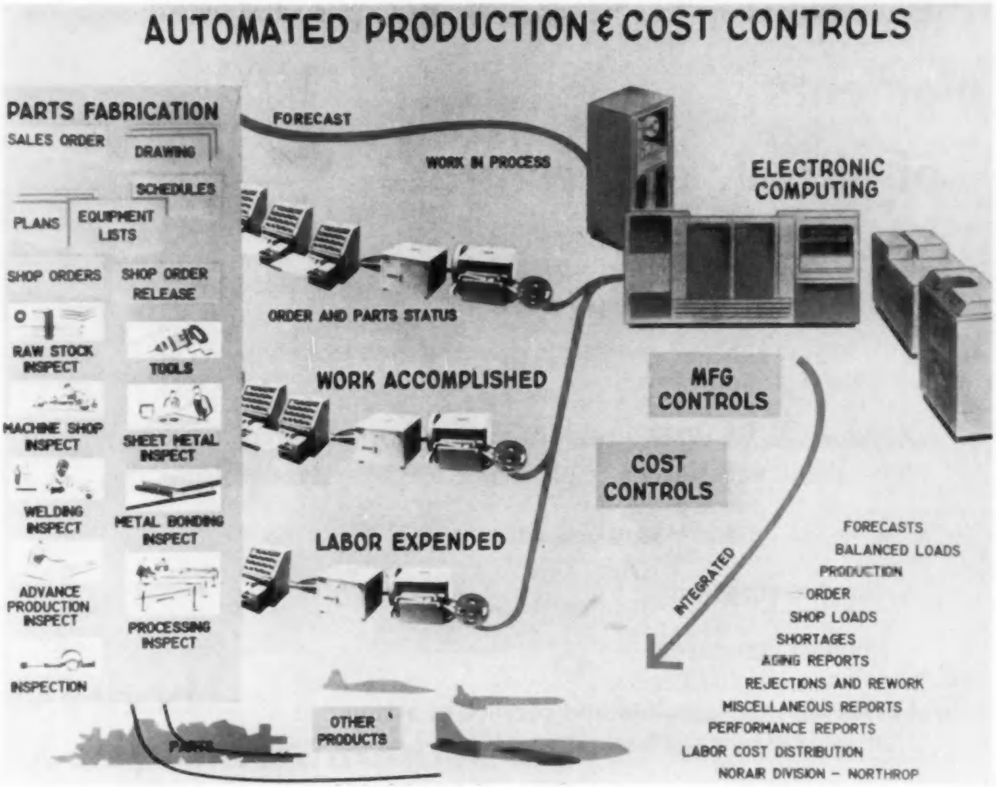
Provide an **INDEPENDENT, NONBIASED REPORTING SYSTEM** which relates the estimated to the actual costs for general and subordinate levels of management.

Incorporate the **"CONTROL BY EXCEPTION"** principle by focusing attention on unfavorable realization.

Fix the **RESPONSIBILITY** for timely corrective action.

Provide the **PERFORMANCE REPORTS** as a byproduct of the operating control data processing system.





How Northrop solved the cost control problem

Management review and proposal adoption

Established a board of review to survey the state of company controls.
Reviewed the report.
Delegated the responsibility for the development of a proposed solution.
Reviewed the proposal at a top management level.
Adopted the proposal.
Formalized the responsibility for implementation policy and organization.
Created cost control engineering group.

Management follow-up and support

Progress reports by implementation personnel.
Adoption of scheduled cost control meetings at various levels of operating personnel.
Maintenance of the "climate for cost control" by all levels of management.

Basic elements

of aircraft cost control

A high quality "statement of work."

A well organized and comprehensive cost estimate. (The "fair" estimate concept)

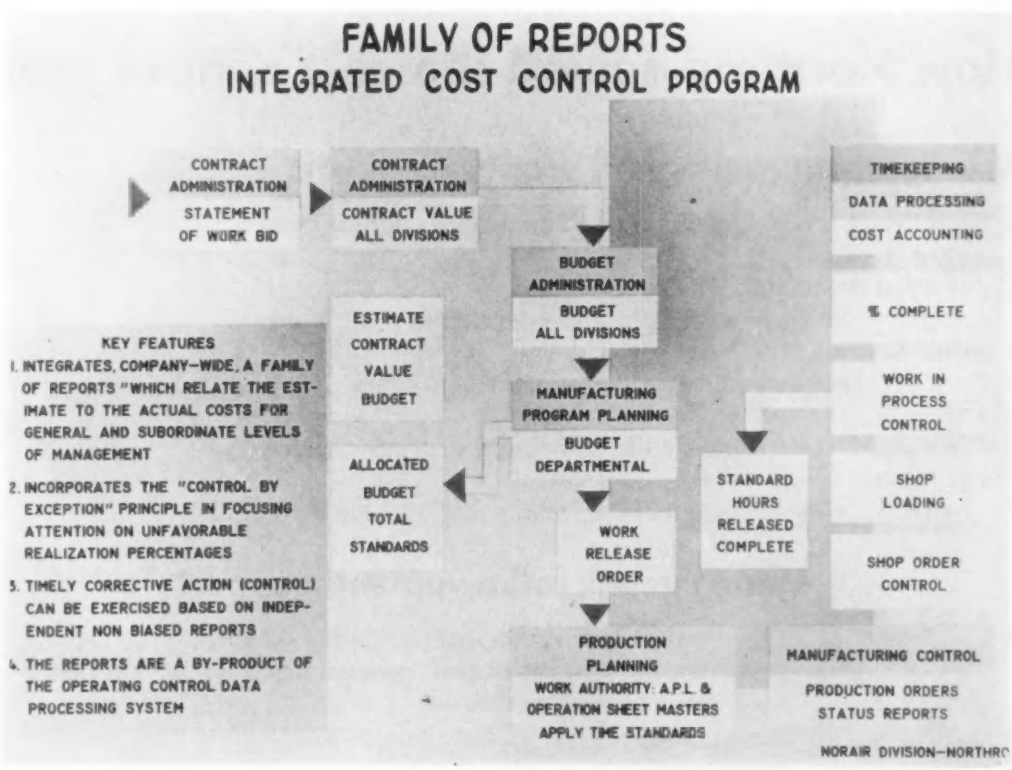
A clear record of "contract value" reflecting original and subsequent negotiations and proper account classifications.

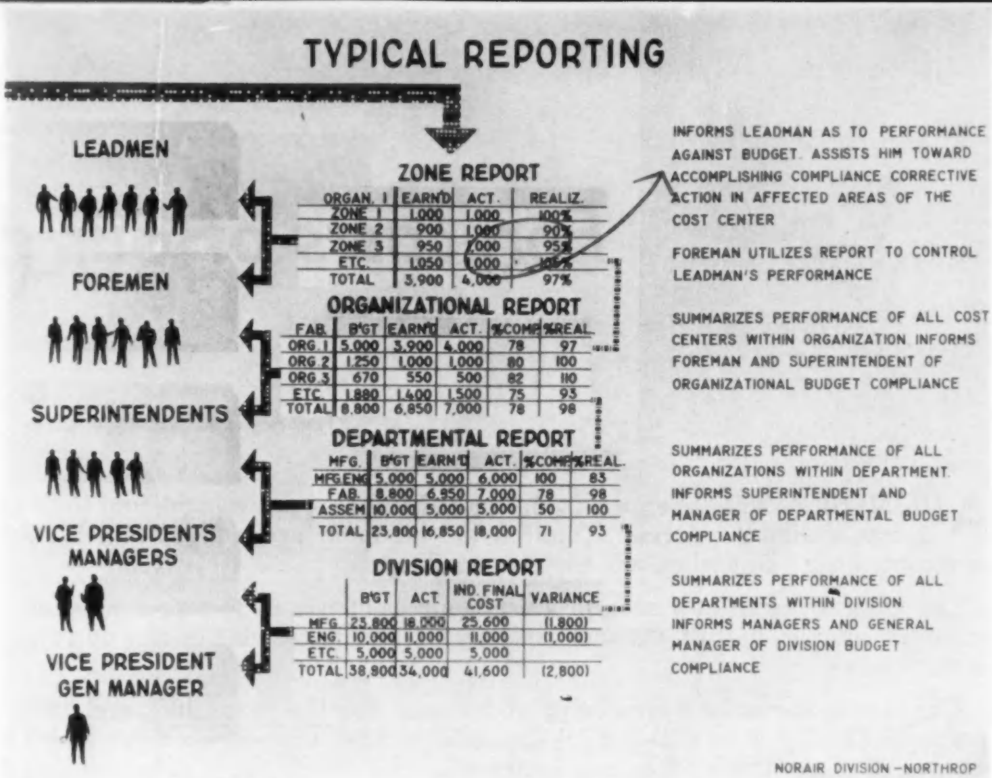
Budgets based on contract value.

Estimated standards.

Planned standards.

Performance evaluation and corrective action.





Method of implementation

Management established the priorities for the implementation program.

A "family of reports" was developed and adopted.

Procedures were developed to fix responsibilities for the affected organizations.

Work authorizations were reviewed and improved controls adopted.

Periodic top-level meetings accelerated the "acceptance" period.

Organization-by-organization implementation was followed to assure proper controls.

Generally adhered to the concept of having the system "ride on operating paperwork" to minimize confusion and re-education.

Specialists in data processing systems were assigned the job of mechanizing the reporting procedures to provide more timely and less costly reports.

Personnel were assigned to the refinement of the system.

Advantages of Program

Current performance at all levels can be related to bid.

For corrective action, variances are pinpointed to all levels according to responsibilities.

Integration provides for "top" report summarization of "bottom" reports.

Control within target.

Accurate historical data provided.

Lends itself to high degree of mechanization of data processing toward lower cost and more timely reports.

Forecasts of our race

Based on paper by

G. W. Sherman

Flight Accessories Laboratory, Wright Air Development Division, Wright-Patterson AFB

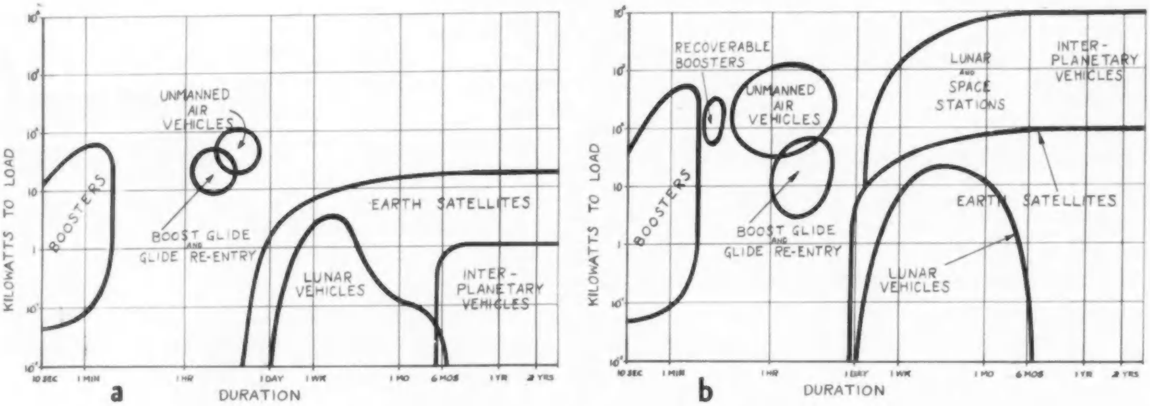
A GLIMPSE of what to expect in the way of future space vehicles and their power sources is now available. Already familiar are the many space flight vehicle concepts evolved in recent times. But when will they be feasible?

The answer lies in how soon practical sources of power become available. Development of power sources, in turn, depends not only on present trends but also on future capabilities and advances.

The charts shown below attempt to forecast, for the years 1962 and 1966, the types of spacecraft that will be within U. S. capability. Also, the sources from which power will be drawn, at these future dates, are indicated. The charts are a simplification and generalization of a complex situation and must be viewed as such. The boundaries depicted are not inflexible but may stretch, as circumstances dictate.

The information on power sources updates some of the material presented in the SAE Journal story of January, 1960, p. 30.

Fig. 1 — **Space Vehicles**

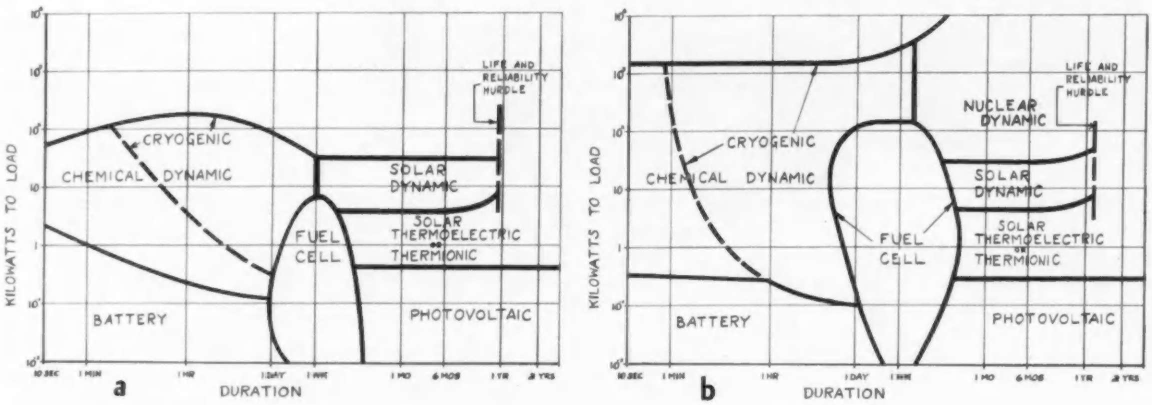


a — By 1962 are forecast space vehicles whose mission duration will range from seconds to years, where power requirements will be from hundredths to hundreds of kilowatts. Boosters and reentry vehicles are expected to draw high quantities of power for relatively short periods, but the highest requirements are expected for unmanned air vehicles. Lunar and interplanetary types will be modest in power drain.

b — By 1966 technology of power development is expected to allow expanded vehicle capabilities as shown. In addition a new category of vehicles, recoverable boosters, will emerge. In general, greater power will be available for all types of space craft, as comparison with Fig. 1a shows. A shorter duration is expected for unmanned air vehicles as a result of an increase of vehicle speed.

to space

Fig. 2 — **Optimum Source of Power**



a — In 1962 optimum power sources for the various applications are expected to be as follows:

Low Power — Short duration: Primary batteries will continue to be the best source.

Long duration: Up to durations of a few weeks fuel cells may be used effectively, but for longer operation photovoltaic power has the edge.

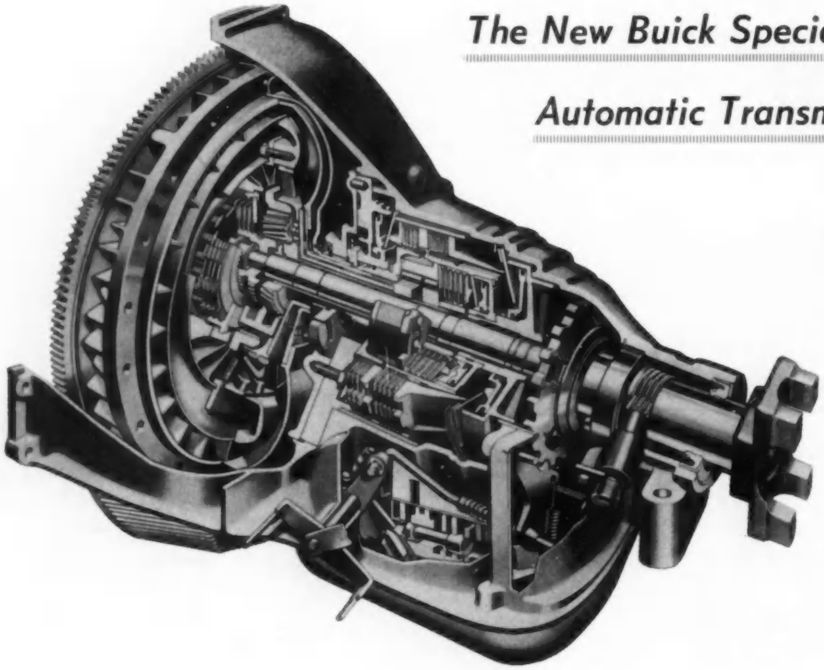
Moderate to High Power —

Short duration: Chemical dynamic power will supply this need with the longer duration applications, up to several days, supplied by cryogenic power. The adaptibility of a cryogenic source for integration with an environmental control system is a major factor in its favor.

Long duration: At moderate power and duration the fuel cell still finds application. For longer periods thermoelectric or thermionic power seems best, or, if higher power is required, a solar dynamic source is optimum. There is a question of whether photovoltaic sources might not overtake the thermoelectric source for higher power applications. Only the relative advances to be made in each of these areas will determine this.

b — By 1966 it is expected that nuclear power will come of age, to handle the severest requirements. Also anticipated is extended usefulness of fuel cells and chemical dynamic sources.

To Order Paper No. 297C . . . from which material for this article was drawn, see p. 6.



The New Buick Special

Automatic Transmission:

The Dual

Based on paper by

Charles S. Chapman and Rudolph J. Gorsky

Buick Motor Division of GMC

THE new Buick Special automatic transmission is a two-speed, "dual path" or split torque transmission of unusual arrangement featuring:

1. Minimum package size.
2. Less weight than the manual transmission.
3. Competitive cost.
4. Smooth operation.

The general arrangement of the transmission makes possible minimum package size. Placing the gear set and direct clutch in the center of the torque converter removes these items from the rear of the unit, which reduces the size of the transmission to the rear of the floor pan toe board providing minimum infringement upon the passenger compartment.

The transmission weighs 84 lb without oil and 95 lb with oil, making cars equipped with this automatic transmission 10 lb lighter than cars equipped with the manual transmission.

Cost studies indicate that the unit is competitive from a cost viewpoint and its simplicity of operation fares well for durability and reliability.

Since the ratio step in the transmission is only 1.58, this unit can be shifted smoothly without difficulty. In addition, the 1.58 ratio in combination with the effective dual capacity of the torque converter gives performance devoid of "holes" of any significance throughout the speed range of the vehicle. The use of the "dual path" or split torque principle provides high efficiency in direct gear.

Transmission arrangement

The general arrangement of the new Buick Special automatic transmission is unusual (Fig. 1). The gear set and direct clutch are located inside the torus of the torque converter. To the rear of the transmission oil pump are the reverse and forward reaction elements, the coast clutch, the stator and sun gear one-way clutches, the parking mechanism, and the governor mechanism. The governor mechanism is fastened to the parking pawl gear and the mechanical governor forces are transmitted to the hydraulic valve in the controls by the governor lever. The general conical shape of the transmission makes possible a single one-piece casting for the transmission case. This transmission is air cooled with the heat being transferred through radial vanes which are cast integrally in the torque converter pump or impeller casting.

Fig. 2 shows the air flow arrangement. Air enters the two passages in the rear of the engine block and travels inwardly between the baffle and the engine block until it reaches holes in the inner portion of the baffle, passes through the baffle and the holes in the flywheel, and out between the flywheel and the torque converter pump or impeller. The radial vanes serve as both heat transfer members and pumping elements. The outlet passages consist of louvers lanced in the torque converter sheet metal

Path Turbine Drive

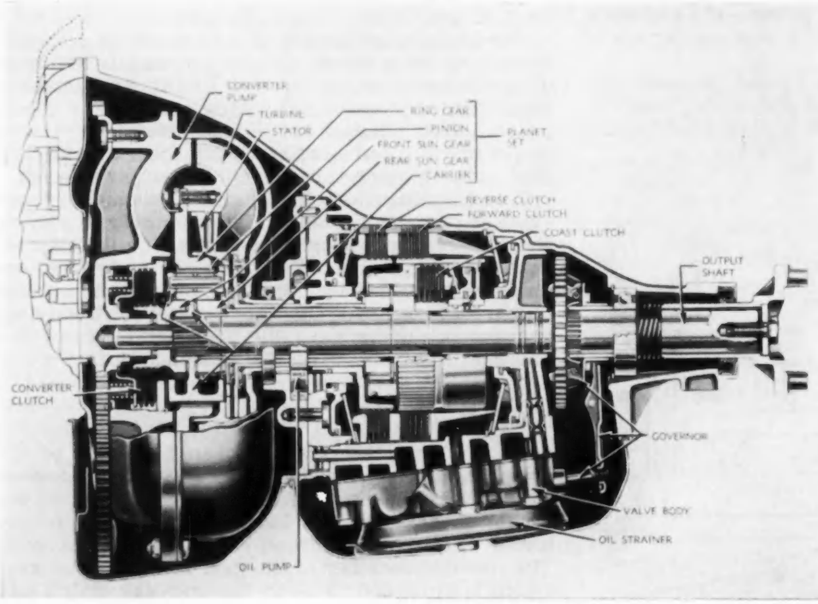


Fig. 1 — General arrangement of the dual path turbine drive — the new Buick Special automatic transmission.

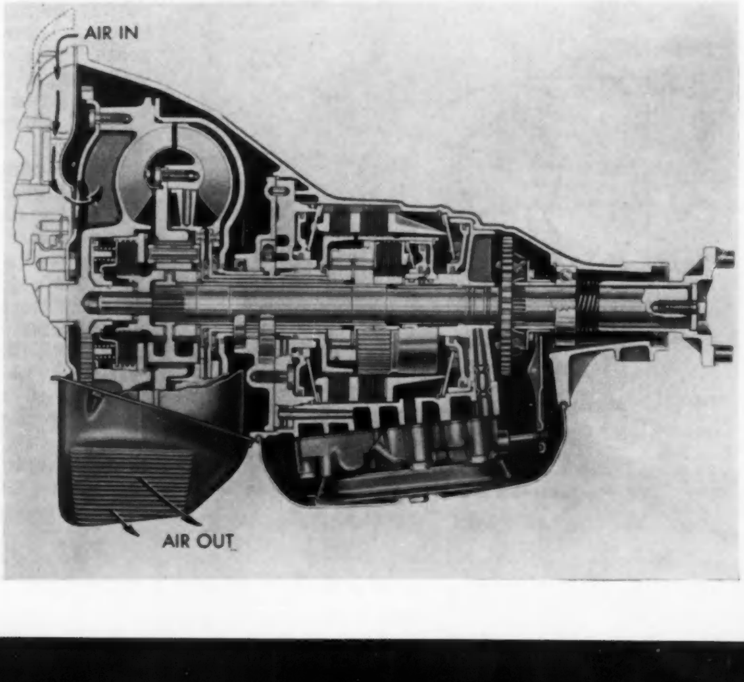


Fig. 2 — Air flow path for cooling the new Buick Special automatic transmission.

Dual Path Turbine Drive

. . . continued

cover on the bottom of the transmission case directly beneath the torque converter.

The use of die cast aluminum converter elements contributes considerably to the weight reduction of this transmission. The pump or impeller member is located in the front of the converter and the radial vanes, which are used as pumping elements and heat transfer elements, also contribute to the stiffness of the casting. The stock thickness of the stamped rear cover could be kept to a minimum since its general shape is stiffer than the generally flat covers used on the front of torque converters of most of the current designs.

The transmission oil pan is also of unusual construction. The pan is fastened with a single bolt in the center and is sealed with a U-shaped rubber gasket which seals between the rolled edge of the pan and the cast groove in the transmission case. The oil pan shape was developed to give the proper spring force to the seal when the single center bolt is tightened. The center bolt in the oil pan also serves as a drain plug. The oil is drained from the transmission by loosening this bolt which allows the oil to drain around the head of the bolt before the removal of the oil pan, eliminating the necessity of a brazed fitting in the pan and an oil plug. A fibre washer is clamped between the head of the bolt and the oil pan. This unusual arrangement has effected a considerable time saving in assembly and in service as well as improving the troublesome leaks which are apt to occur if the conventional oil pan and gaskets are not handled carefully. The bullet type parking pawl mechanism resembles that used on a Chevrolet transmission. Since this arrangement fitted so well into the Special package and is a low cost and functionally reliable mechanism, it was used.

The shaft bearings are cast in place by a special process which permits a reduction in the diameter of the concentric shafts used in this transmission since the normal steel backing member is eliminated. The elimination of the steel part of the sleeve bearing reduces the radial space required to that actually necessary for the bearing material.

The transmission oil pump is a compact two-stage slipper-type pump. The two stages provide the generous capacity needed for engine idle requirements and when the hydraulic system oil requirements are reduced as they are at road load and higher speeds, only the inner stage of the pump operates which reduces the parasitic losses of the pump without any excessive complication.

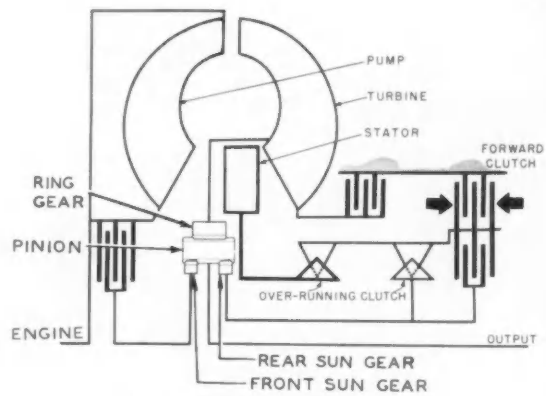


Fig. 3 — Power flow in first gear of drive range.

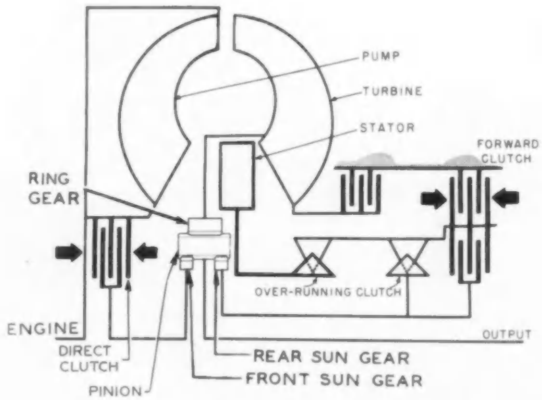


Fig. 4 — Power flow in direct gear of drive range.

Power flow

Fig. 3 shows the power flow in first gear of the drive range. The turbine of the three element torque converter is fastened to the ring gear of the planetary gear set and 100% of the engine torque passes through the torque converter in first gear. The reaction member of the gear set is the sun gear which is grounded through the one-way clutch and forward reaction member. The planet carrier, the output member, is fastened to the output shaft through the web of the carrier between the two sun gears. The gear ratio of 1.58 combined with the stall torque ratio of the torque converter of 2.50 gives an overall ratio of 3.95 at stall.

Fig. 4 shows the arrangement in direct gear of drive range. The application of the direct clutch gives the "dual path" or split torque feature. The front sun gear is connected mechanically to the engine by the direct clutch. The two sun gears rotate at the same speed. Part of the engine torque is transmitted through the torque converter to the ring gear and part is transmitted through the direct clutch to the sun gear. Since the carrier is the output member, the planet pinions act as balancing levers with fulcrums at the pinion pins in the planet carrier. The ratio of fluid torque is therefore a function of the radii of the sun gear and the ring gear, and the particular ratio used gives a torque split of 63.4% carried by the torque converter and 36.6% transmitted mechanically to the clutch and sun gear. Since the effect upon torque converter

capacity of a change in input torque is an exponential function, the effect upon the torque converter slip is greater than these percentages indicate. The forward reaction element remains engaged in direct to provide a reaction for the stator one-way clutch. In direct gear at road load the inner races of the one-way clutch units turn freely and are ready for engagement whenever a torque reversal takes place. The kick-down maneuver is accomplished by releasing the direct clutch.

Low range (Fig. 5) is similar to first gear of drive range except that the coast clutch is applied for downhill engine braking. The purpose of the coast clutch is to lock the rear sun gear overrunning clutch in the free-wheeling direction. It may appear that the 1.58 low gear ratio is mild for downhill braking, but the ratio of the propeller shaft speed to the vehicle speed must be considered. The preliminary specifications for this vehicle called for this ratio (N/V) in the range of 43 to 46 in direct gear to provide pleasant midrange performance in both the automatic transmission and synchromesh cars. With an N/V ratio in direct gear of 43.5, the low gear N/V is 69. This compares favorably with the N/V of 67 used in low range in the current turbine drive transmission in the LeSabre model, which has given creditable field service.

In reverse range (Fig. 6), the reverse reaction member and the coast clutch are energized. Applying the reverse reaction element grounds the turbine and the planetary gear set ring gear. The turbine now becomes the torque converter reaction member and drives the stator backwards, the stator becoming the output member. The stator turns the one-way clutch outer race backward through the stator one-way clutch. The coast clutch is fastened to the rear sun gear shaft and turns the rear sun gear backward, and application of the coast clutch is necessary in this instance since this is the free-

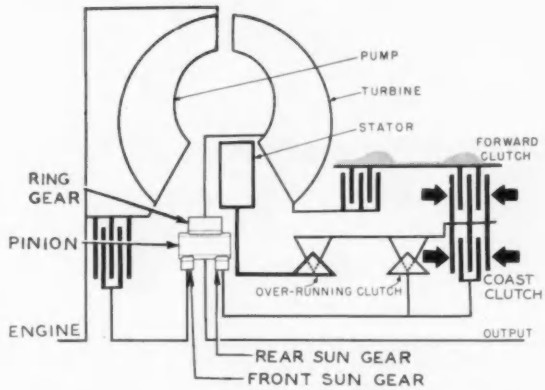


Fig. 5 — Low range is similar to first gear of drive range except that the coast clutch is applied for downhill engine braking.

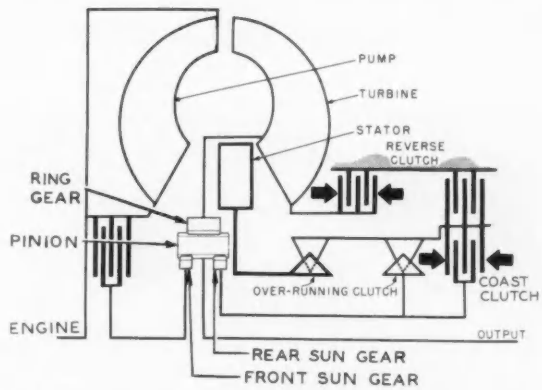


Fig. 6 — In reverse range, the turbine becomes the torque converter reaction member and drives the stator backwards, the stator becoming the output member.

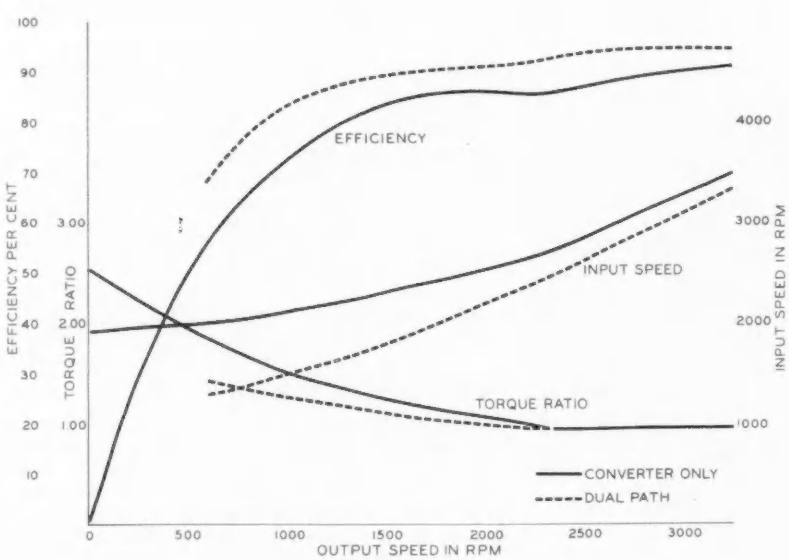


Fig. 7 — Dual path converter performance — 150 lb-ft input torque.

wheeling direction of the sun gear one-way clutch. Since the ring gear is grounded through the turbine, the planetary gear set is now underdriven in the reverse direction with a ratio of 2.73. The stator torque of 1.50 multiplied by this gear set ratio is an overall ratio of 4.10 in reverse at stall. This is probably the first passenger car application of "stator-reverse."

In neutral the only friction element applied is the coast clutch which is applied so that the inner and outer races of the one-way clutches rotate together. Because of the high rearward speed of the one-way clutches in neutral, the rollers tend to lift off the inner races due to centrifugal force. Application of the coast clutch insures that the races are synchronized before they are required to engage when shifting from either forward or reverse.

The dual path arrangement

The arrangement of the torque converter and gearset in this transmission makes it possible to obtain the split torque or "dual path" feature without undue complication. This is the first commercial passenger car application using this principle with a torque converter. Its use with a two-speed transmission provides several advantages. First, a higher stall speed torque converter can be used which permits acceptable performance at higher altitude and improved converter extension at sea level without sacrificing road load economy. The torque converter size is then primarily dictated by the performance extension desired in the "dual path" or split torque range. The benefits derived in direct gear efficiency are shown in Fig. 7 for the particular size torque converter selected. Note that the effective change in torque converter capacity which this principle yields in effect raises the efficiency considerably. Another beneficial design result is that the higher stall speed converter permits the use of a smaller diameter unit with resultant benefits in ground clearance and package size. Also, the use of this principle permits the use of a relatively mild first gear ratio (1.58) which gives a more satisfactory highway passing range than any known two-speed transmission. The effect of the "dual path" power flow coupled with this gear ratio in effect gives a larger effective passing ratio at lower speeds because of the torque converter extension with the high stall speed converter, as well as a small effective step at higher speeds because the differences in converter diameter are less effective at higher speed ratios where the variation in slip in the coupling range is percentage-wise very small.

To Order Paper No. 290B . . .
from which material for this article was drawn, see p. 6.

Service experience with transistorized ignition

Based on paper by

J. F. Gage and C. J. Dunne

Electric Autolite Co.

TRANSISTOR-switched ignition systems reduce contact "bluing" and erosion sufficiently to increase contact life to many times that experienced with conventional ignition systems, recent tests indicate. But, to give entirely satisfactory performance, the ballast and coils of the transistor system tested require some correction.

Fig. 1 shows the circuit diagram of the transistorized ignition system studied in the field and by test. The field tests involved 40 such systems used in as many trucks, buses, highway patrol cars, private passenger cars, taxicabs, and stationary engines. To gain a complete picture of the field acceptance and advantages, a package was supplied with each installation. It contained the coil and ballast already mounted on a heavy steel bracket, the heat sink, and a set of installation instructions.

Installation no problem

It was left to the mechanic to mount the unit and in only two instances was the ground connection found to be inadequate. The instructions called for mounting the heat sink where the ambient would not exceed 170 F, and almost all units were found to be in some under-hood location. Nevertheless, none of the malfunctions which were found could be attributed to temperature-induced failures.

Prior to installation of the transistorized system,

cold-weather starting of taxis in the morning required an attempted starting of 50 to get 25 going. The failure to start was due in part to "blue" contacts and in part to low ignition voltage caused by low battery voltage. No such failures were reported for the transistorized systems.

Causes of failure

Complete failure and powerplant immobilization could occur with a transistorized ignition system if overvoltage spikes persist across the transistor or extremely high currents are passed for only a short time. Therefore, coil, ballast, and circuitry have to perform without a flaw.

It was found that the ballast had to be designed to handle the 8–10 amp of primary current without fail because of the field practice of shorting out malfunctioning units. This fix will work long enough to get a vehicle to a repair station. But it won't work with a transistor system because of the lower primary resistance. Shorting the ballast will cause high currents, which result in destruction of the transistor or, at best, a very short operating period.

Coils were the major cause of malfunction. With the exception of a few secondary winding failures, internal arc-over of the high secondary voltage to the primary circuit caused voltage breakdown of the transistor. Coil redesign was then undertaken to insure that mechanical spacing and quantity of dielectric material were always sufficient to prevent internal flashover regardless of mounting attitude or ambient temperature or both.

Effect of coil on other components

There were a few isolated cases of distributor cap tracking, otherwise there were no reported premature failures of components. The greater output energy of the transistor system was apparently sufficent to overcome leakage associated with fouled plugs and still allow buildup to required firing voltages.

The undesirable effect of the lower frequency output of the transistor ignition coil (Fig. 2) was the greatly increased period of time during which the available voltage was sufficient to maintain plug firing. As the spark plug firing continued, the spark length between distributor rotor and cap inserts was drawn out across the cap surface between the inserts. Eventually, this established a carbonized track on the cap surface, reducing the effective insert-to-insert spacing, and arc-over caused irregular firing (Fig. 3).

Although the incidence of cap tracking was very low, the coil has been redesigned so that output voltage amplitude and frequency of the transistor ignition system agree with the characteristics of the conventional system and are compatible with its components. Nevertheless, there is still need for the previous close-coupled, low-frequency coil by which higher voltages, or higher energy outputs, or both can be obtained for nonfouling ignition, multifuel engine ignition, and ignition systems for cold-starting diesels.

To Order Paper No. 306A . . .
from which material for this article was drawn, see p. 6.

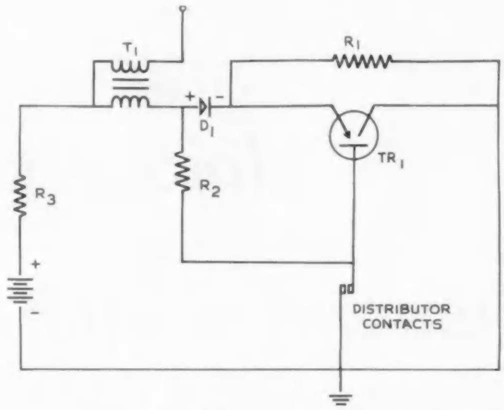


Fig. 1 — Circuit diagram of transistor-switching, high-voltage, ignition system, field-tested in trucks, buses, highway patrol cars, private cars, taxis, and stationary engines.

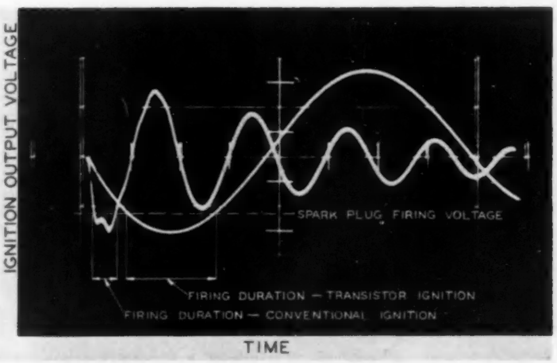


Fig. 2 — Longer firing duration of transistor ignition system caused by lower frequency output led to occasional cap tracking. Correction was made by redesigning coil to make voltage amplitude and frequency compatible with conventional system characteristics.

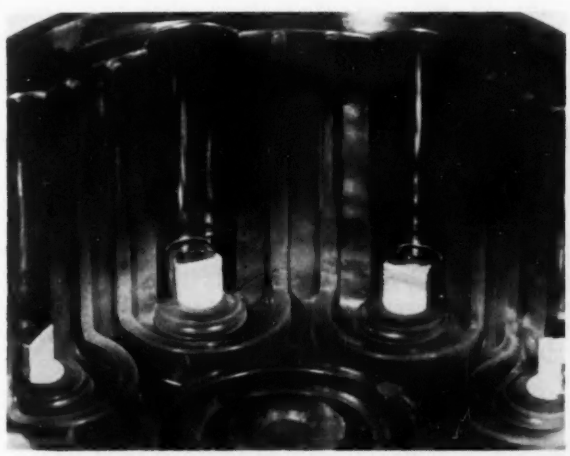


Fig. 3 — Example of carbonized track on cap surface between inserts. The conductive paths permitted arc-over to cause irregular spark plug firing.

Unique propellant hazards demand unique handling methods

Based on report by secretary

D. H. Wayman

Marquardt Corp.

THE HAZARDS associated with propellants are unique. Besides flammability in air, many propellants react with water; are unstable and may explode under shock, at high temperatures, or when contaminated; are toxic; react more rapidly than hydrocarbons. This article touches on some of the more important areas associated with propellant handling — training techniques, medical aspects, and contamination control. The handling of liquid and gaseous hydrogen, and handling techniques utilized in testing liquid and solid rockets also are discussed.

Training techniques

Before an effective training program can be started, the vast amount of information on chemicals used as propellants must be sifted, evaluated, selected, and organized into a training manual which should include a discussion of properties that affect handling, system design criteria, and operating guides.

Training at Marquardt Corp. begins with a series of 1-hr lectures. Propellant terms and the general rules and procedures which apply specifically to testing in the Air Force — Marquardt Jet Laboratory are first introduced. It is important to distinguish between FUELS, OXIDIZERS, and MONOPROPELLANTS and to associate the hazards and handling precautions which are specific for each class of propellants.

Each propellant is then described, starting with the hazardous properties which each presents to uninformed personnel and the precautions which must be taken to use each propellant safely. Compatible materials for system construction are specified, plus the necessary cleaning and passivation steps. System design features are illustrated using simple schematics.

A second feature of the formal training program includes demonstrations and movies. The safety equipment available for personnel protection is demonstrated — when and how to use it, and why it must be used. Fire fighting and some of the more graphic propellant terms are demonstrated: pyrofori̇c, hypergolic, compatible, catalyst. A tour of the storage areas serves to familiarize personnel with the various drums, cylinders, and ready storage tanks in which propellants are shipped and stored.

A mark of 70% is required on examinations to satisfactorily complete the course. Graduates of the course, who physically qualify, can then be paired with more experienced men and assigned to increasingly complex propellant use tasks.

Medical aspects of propellant handling

At Aerojet-General propellants are divided into three health hazard classes: those which have been used for a long time in large quantities (jet fuels, liquid oxygen, fuming nitric acid, aniline); those which are used in development quantities (hydrazine, uns-dimethylhydrazine, other hydrazine derivatives, nitrogen tetroxide); special problem propellants (boranes, fluorine compounds, beryllium).

Those propellants which have been around for a long time usually don't require much service from the health department except for an occasional burn. Those in the development class, such as hydrazine, have resulted in caustic burns and some anxiety by personnel concerning cumulative effects. When uns-dimethylhydrazine first came on the market, it contained an intermediate impurity which did cause residual liver damage, but present UDMH is now less toxic than other hydrazine derivatives.

The special problem propellants must be treated differently. With the boranes, this is handled by training, not only of the men but of their wives and families. They are asked to observe and report any unusual behavior pattern of the men. Because borane intoxication is insidious, the effects are delayed and the awareness center is impaired, it is important for the family to recognize the symptoms and report them.

Beryllium poisoning is impossible to diagnose at present, and very little is known about the chronic and delayed effects. It is also difficult to perform research studies because apparently not everybody is susceptible and laboratory animals do not develop chronic effects. There isn't much chance that the present two micrograms per cubic meter tolerance will be relaxed appreciably until much more information has been accumulated.

Fluorine compounds present both acute and residual toxic problems as well as burns. Present burn treatments are not satisfactory; neither the calcium gluconate nor the Zifferin compounds.

Health protection at Aerojet includes pre-employment physicals and rechecks at six month intervals. These include chest X-ray, blood count, urinanalysis plus microscopic examination, and liver function tests. Incipient conditions which might result from propellant exposures are so similar to those produced by many other health problems that the doctor usually must rely on departures from a man's normal physical condition. At Aerojet, sufficient time is spent talking to each man during his physical to find out how he feels. This is the best means available for spotting differences in general health, which can be investigated further.

There is an urgent need for systematically acquiring new guide lines to assess the hazards to personnel from acute exposures and repeated small exposures to chemical propellants. Better diagnostic tests and treatment methods also are required.

THE TOTAL HAZARD CONTROL CONCEPT of handling propellants consists of four phases:

- Determination of the dangers to personnel and property which each propellant and propellant combination present.
- Design of storage and test facilities to minimize the hazards to operating personnel and to the public.
- Preparation of detailed procedures to govern the five operational phases of propellant use: storage, transport, transfer to and from storage containers, transfer to test stands, and testing.
- Training of personnel to provide an appreciation of propellant hazards and an understanding of the procedures and techniques necessary

Contamination control in propellant systems

Within the past few years, the techniques for recognition, classification, removal, and analysis of contaminants in propellants and missile hardware have reached an advanced state of sophistication. The recognition of various types of contaminants, from "exploding" fingerprints to old sandwich wrappers, first established the need for stricter fabrication controls, through cleaning methods and more effective filtering media.

Prior to 1958–59 at Rocketdyne, filters were made from cheesecloth, paper elements, hardware cloth, household screening, wire-wound elements, sintered metal or ceramic elements, and woven wire cloth. Inspection techniques were random and consisted principally of visual examination and elementary chemical analysis. Cleaning by solvent degreasing was deemed adequate and only a few general requirements were placed on fabrication, cleaning, and assembly areas.

Since 1959, contamination control has been extended from raw material to finished product and rigid specifications and procedures are used to assure adequate finished product cleanliness.

Procedures have been written to cover fabrication, assembly, testing, inspection, packaging, and handling of hardware. Cleaning processes are specified and quantitative cleanliness standards have been established. Particulate contamination is measured using standardized washing, filtering, weighing, and counting techniques. Results are reported as the number of particles and fibers in each size range and their total weight per unit area.

Limits on hydrocarbon content, water, and carbon dioxide have been established for propellants, gases, testing fluids, and systems. These impurities are determined by the latest chemical (solvent extraction) and physical (spectroscopic) methods and are reported as milligrams of a standard per unit of area. Visual inspection is also applied in most cases.

Increasing attention is being directed to the cleanliness of assembly and inspection areas. Special materials and procedures are used in a rigid environmental maintenance program. These areas are constructed to facilitate maintenance and minimize dust accumulation; for example, stainless steel walls and shelving, non-flaking floors. These areas are constantly monitored for suspended particulate contamination. The air is sampled by millipore filtration and reported as the number of particles per cubic foot of air plus their size distribution.

Improvements have been made in the filters used in propellant and gas lines. Woven wire mesh elements of specified materials with nominal pore sizes (microns) generally are used.

Handling liquid and gaseous hydrogen

Hydrogen is colorless, odorless, non-toxic, and non-corrosive in both the liquid and gas phases. As a gas, it diffuses rapidly and is combustible over a wide range of mixtures with oxygen and air (4–74% by volume). Hazards associated with the liquid phase are those common to all cryogenic systems: (1) low temperature structural failure of materials; (2) closed system pressure increase during confined fluid phase change; (3) physiological effects resulting from exposure to severe cold or oxygen-deficient atmospheres.

Liquid hydrogen still retains its fuel properties: it forms flammable mixtures with air and other oxidizers and its high autoignition temperature is offset by the low ignition energy required — 0.02 millijoules in air — or one-tenth that of typical hydrocarbons. Safe use of liquid hydrogen depends, principally, on preventing combustible mixtures in the presence of ignition sources.

In the area of material selection for liquid hydrogen systems, the low temperature embrittlement of ordinary carbon steel is well known. However, many other structural materials are suitable for cryogenic system use; for example, aluminum, copper, nickel, and austenitic stainless steels. A good correlation has been made between the brittle behavior of metals and alloys at low temperatures and the crystal lattice structure of these materials. Face-cen-

Unique propellant hazards

. . . continued

tered cubic metals and alloys do not become brittle; body-centered cubic ones do.

The hazard presented by phase change pressurization can be minimized by proper system design. All isolated portions of the system must be provided with pressure relief devices.

The hazard to personnel from low temperature "burns" and oxygen-deficient atmospheres can be eliminated by training and adequately marking cold lines.

System design features of a typical liquid hydrogen pump test facility include a control room for personnel and instrumentation, supply dewars, transfer lines, vent system, valves, and a concrete protective wall between the control room and the test stand.

The control room features explosion-proof electrical equipment, adequate ventilation from vents and blowers located at the high point of the room, elimination of all open flame sources, common ground for all equipment, conductive floors, grounding bars for personnel and conductive clothing and shoes for operating personnel.

All hydrogen-containing equipment would best be located outdoors in an unconfined area to allow leaking hydrogen to dissipate readily.

Soap-and-water cleanliness is adequate for hydrogen systems, but all potential solid contaminants must be removed by a series of evacuation and purge cycles — initially with dry nitrogen and then with gaseous hydrogen. Lines charged with hydrogen must be maintained at a slight positive pressure.

The final choice of venting procedure (to flare or not to flare) depends on conditions existing at each facility, since both methods are hazardous. If the gas is flared, provision must be made to prevent flashback down the stack; if it is not flared, reasonable precautions must be taken to prevent ignition by electrostatic or other sources.

A protective concrete wall provides personnel with a physical and psychological protection. More than one wall or a roof is dangerous because confinement enhances the possibility of detonation.

Handling techniques for testing liquid and solid rockets

The rocket test facility at ARO, Inc., was initially conceived and constructed to provide a captive testing capability for propulsion systems for subsonic to Mach 20 speeds at altitudes to 100,000 ft. Seven test cells, ranging in diameter from a few to twenty feet and connected to a common air supply and exhauster facilities through necessary valves and ducting are now operating on a continuous week basis. Temperature and humidity controlled air can be continuously delivered at 500 lb per sec at unaugmented altitudes of 80,000 ft. Using steam ejectors and other devices, altitudes in excess of 100,000 ft can be obtained and mass flows to 1000 lb per sec can be provided for a short time.

Because of the common air and exhauster systems, the test cells are necessarily close together, which provides challenging operational problems. These problems have been solved by a combination of scheduling, procedural controls, personnel training, and test area isolation. Solid propellant rockets up to a 4000 lb charge and liquid propellant rockets which develop up to 20,000 lb of thrust, have been safely tested.

Detailed control procedures have been written to define each phase of propellant use. Maximum controls are in effect during solid propellant transport, preparation, and firing. Three stages of isolation and evacuation are provided to control the movement of personnel within the test facility. The minimum hazard condition, called local evacuation, is in effect during the period when liquid propellants are in ready storage. This condition is indicated by boundary ropes and personnel movement into these areas is restricted.

An intermediate evacuation condition, represented by solid propellant preparation and storage areas, is indicated by yellow flashing lights, ropes, and a badge control board. Strict personnel movement control into these areas is maintained. The number of people allowed into such areas is minimized and they are accounted for by a badge exchange system.

During the most hazardous condition, represented by solid propellant loading in a test cell and all test firings, main evacuation is employed and the location of all personnel is determined by a badge control and check-off system. The extent of areas to be evacuated are determined for each test during a pre-test preparation conference. Detailed check lists and procedures covering all phases of the test are prepared at this conference. For example, 500 lb solid charges are moved at all times with intermediate evacuation conditions applied. Over 500 lb charges are moved only at night and under main evacuation conditions.

Other operational and facility design features include a remote bulk storage liquid propellant area several miles from the test facility. Trailers are used as ready storage tanks and to transport propellants to the operational (run) tanks. These tanks are always located exterior to the test cells in catch basins. When toxic propellants are used (nitrogen tetroxide, boranes, hydrazines) these run tanks are enclosed and the vent gases are passed through a steam ejector before entering the atmosphere.

Toxic wastes from combustion tests are scrubbed with water which is collected in a settling reservior. It can be treated with appropriate chemicals to neutralize and detoxify before release into natural streams.

SERVING on the panel which developed the information in this article, in addition to the panel secretary, were: chairman **R. A. Sforzini,** The Marquardt Corp.; co-chairman **F. T. Schuler,** North American Aviation, Inc.; **H. M. Cook,** ARO, Inc.; **R. M. Hill,** Los Angeles Fire Dept.; **A. F. Schmidt,** National Bureau of Standards; and **B. D. Culver,** Aerojet-General Corp.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on page 6.

Electroplated coatings

control

space vehicle temperatures

Based on report by **M. E. Carlisle,** Northrop Corp.

ELECTROPLATED COATINGS are being used to control the temperature of vehicles orbiting in space. In outer space, temperature control is relatively simple — the only way heat can enter or leave is by radiation or by actual expulsion of matter from the space vehicle. (Temperature control in the earth's atmosphere, on the other hand, is complicated by heat loss or gain by convection, conduction, and radiation.)

The law of radiation states that the energy radiating from a surface follows the formula:

$$P = 5.73 \times 10^{-12}\, ET^4A$$

P = Total radiation, watts
E = Emissivity
T = Temperature, deg K
A = Area, sq cm
5.73×10^{-12} = Stefan-Boltzman constant

E is the radiation efficiency of emission or the ratio of the energy radiated by a particular surface to the energy radiated by a perfect black body at the same temperature. Emissivities vary from 0.9 for oxidized surfaces of 19–9 steel to less than 0.1 for a mirror surface of gold, silver, or aluminum. Therefore, to retain heat in space, the vehicle should be coated with one of the low-emissivity metals. Silver is not practical to use because it tarnishes easily, losing its low emissivity. Aluminum cannot be deposited from an aqueous bath, and vacuum coating of aluminum is as costly as gold plating.

Gold plating seems to be the most practical solution to the problem, but some difficulty has been encountered in plating to the necessary thickness. When gold is too thin, it promotes corrosion of the base metal and diffuses completely into the base metal changing the emissivity characteristics of the surface. There are two approaches to this problem: (1) to undercoat with nickel, making sure that the nickel is pore-free and (2) development of new techniques for plating with gold.

High emissivity coatings are used when you want maximum radiation. The best coating outside of graphite is a simple heat scale on 19–9 steel with an emissivity of 0.9 or heat scaled type 309 stainless steel with an emissivity of 0.8.

The radiation characteristics of a material can be used to control the temperature inside a vehicle The key factor to be evaluated is the A (solar absorptivity) to E (ambient emissivity) ratio.

Fig. 1 shows the spectral reflectivity of aluminum and white paint. Solar energy is absorbed at an 0.5 micron wavelength. Even though aluminum is a better reflector than white paint, the aluminum-coated vehicle would be hotter because it cannot emit the heat it absorbs. Table 1 runs through the comparative calculations and shows the white-painted vehicle would be at 75 F and the aluminum-coated vehicle would be at 102.5 F. For this reason, the coatings on future space vehicles will have special requirements and will call for new specialized techniques for application.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.)

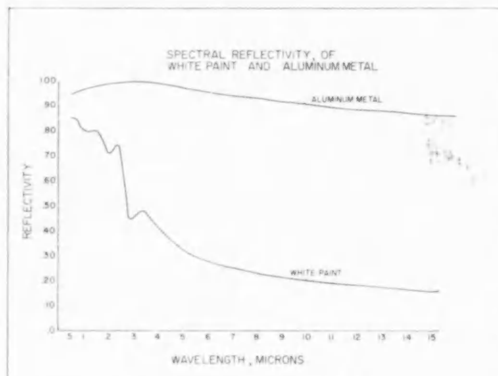


Fig. 1 — Spectral reflectivity of white paint and aluminum metal. Although the aluminum is a better reflector than the white paint, the aluminum coated vehicle would be hotter because it can't emit the heat it absorbs.

**Table 1 — Absorptivity — Emissivity
White Paint vs. Aluminum Coat**

White Paint		Aluminum
0.85	(1) Solar reflectivity	0.95
0.15	(2) solar absorptivity	0.05
0.80	(3) ambient emissivity	0.10
0.20	(4) heat not emitted	0.90
0.03	(2) × (4)	0.045
75 F	actual temperature	102.5 F

High-speed VTOL aircraft

can now be built to solve problems of short-haul, mass transportation

Based on paper by **H. V. Borst and J. M. Mergen**
Propeller Division, Curtiss-Wright Corp.

WHAT operators of local service airlines want in a VTOL transport is a cruise speed of 300–400 mph, seating capacity for 50 passengers, and a range of 500 miles. They also want a pressurized cabin, a relatively high cargo capacity, and safe operation.

All this is promised with a proposed high-speed VTOL, designated Model 300, which is based upon already successfully tested designs (Fig. 1). It is a 4-engine, tandem-wing aircraft with four tilt propellers mounted on the nacelles located at the wing tips. The engines remain fixed in the nacelles and are intershafted so that any combination of engines can continuously drive all four propellers. The aircraft has an all-metal, semimonocoque construction, a pressurized cabin, fully retractable landing gear, and is equipped for all-weather operation. The Model 300 weighs about 44,000 lb, is 73 ft long, 64 ft wide, 24 ft high, and the design cruise speed is 300 knots at 10,000 ft.

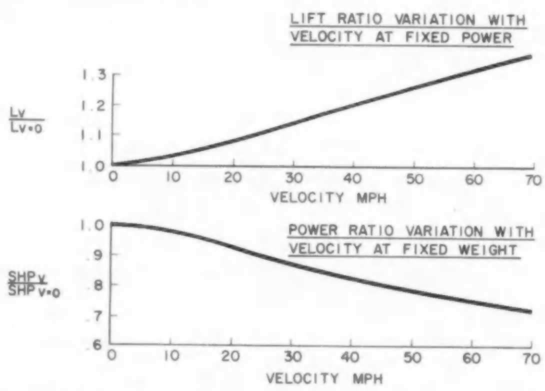


Fig. 2 — As forward speed of Model 300 aircraft is increased, a reduction of power to maintain flight occurs, or take-off weight can be increased. Thus, take-off performance can be increased without relaxing safety requirements if speed is gained before reaching an altitude of 25–50 ft.

Tandem-wing advantages

The tandem-wing configuration does not require cycle pitch change or flapping propeller blades, hence it is possible to use highly developed, conventional propellers with rigid blade retention. This is extremely important in an aircraft dependent on propellers or rotors for lift during any position of the flight regime. The configuration allows a relatively large c.g. travel as compared with more conventional aircraft. Moreover, wind tunnel testing proves stability and control to equal that of fixed-wing aircraft. Flight control surfaces are all located on the rear wing. Elevators are used inboard on the rear wing for pitch control, and ailerons outboard on the rear wing. A conventional rudder is used for yaw control.

Safety provisions

If the aircraft is to be operated in highly restricted areas where vertical rises of several hundred feet must be made to clear obstacles, or take-off and landings from rooftops is desired, the VTOL must be capable of hovering out of ground effect with one engine inoperative. This requirement is essential because the aircraft must be capable of returning to its original take-off location in a safe manner.

As the forward speed is increased, less power is needed to maintain flight, or take-off weight can be increased (Fig. 2). Thus, if the aircraft is allowed to gain speed before reaching an altitude of 25–50 ft it is possible to increase the take-off performance without relaxing the safety requirements. By taking advantage of this transitional lift, it is possible to improve the payload-range capability; and in the case of engine failure at the critical speed, flight on the remaining engines will be possible and the aircraft can return to its landing pad with a small forward speed.

Redundancy assures that no single failure will be catastrophic. Gearboxes and shafts can fail without disastrous results, provided the engines are operating or, if an engine failure does occur, the aircraft can continue its flight and make a safe landing.

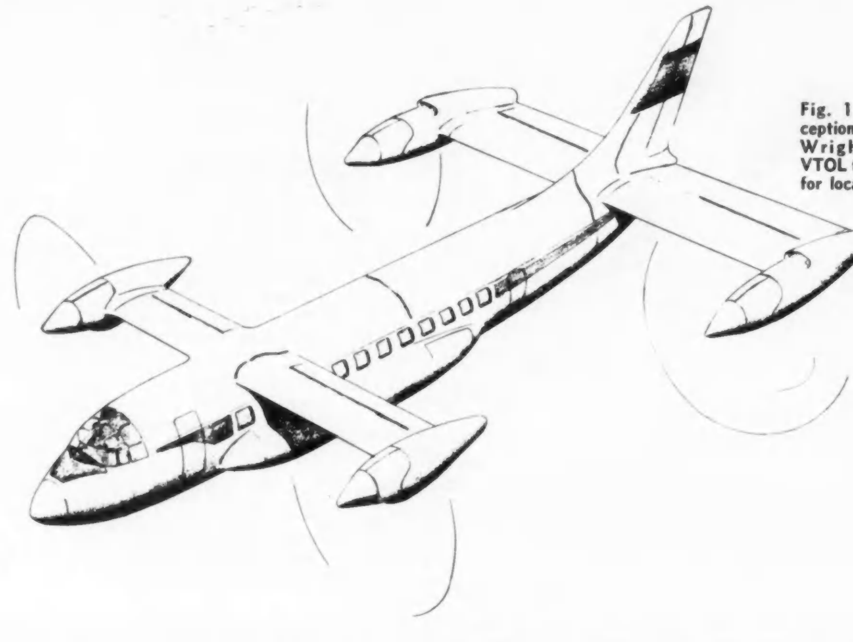


Fig. 1 — Artist's conception of the Curtiss-Wright, Model 300, VTOL transport designed for local service airlines.

With a wing loading of 80 psf, the power-off stall speed is approximately 100 knots with the flaps extended. Flight controls have been designed to be effective at this speed so that the aircraft is controllable in case of a total power failure. The power-off landing speed would then be 120 knots, or approximately that of conventional aircraft.

Noise and wake velocity

The low tip speed and loading of propellers makes this type of aircraft inherently quiet. At 3000 ft the noise level is approximately the same as that of an average residential area.

Although the disc loading of the Model 300 is higher than that of a helicopter, the wake velocity affecting people around the aircraft will be about the same. Standing near the aircraft during its take-off will be less objectionable than standing in back of a conventional one when it is pulling away from the ramp.

Performance characteristics

Changes in performance due to variations of temperature and altitude are characteristic of turbine engines. For instance, on a sea-level standard day, the Model 300 can take off at 49,000 lb from a vertiport, whereas on a sea-level 100-deg day the takeoff gross weight is reduced to 40,000 lb. Water injection might improve hot-day take-off considerably. The translational lift characteristics allow an increase in gross weight of 10% for heliport operation, so that the allowable gross weight on a sea-level standard day becomes 54,500 lb.

Even at the high gross weights, rates of climb in excess of 2000 fpm are obtained at speeds of 300 knots. And this is important because high rate of climb reduces block speed. The Model 300 is capable of speeds equal to or higher than the equipment now being used by local service airlines (Fig. 3).

To Order Paper No. 266G . . .
from which material for this article was drawn, see p. 6.

The promise of the VTOL

STUDIES place the cost per seat-mile of the Curtiss-Wright, proposed Model 300 VTOL at 3.4¢. Similar costs for conventional aircraft on local service airlines run 2.5–3.1¢.

The nemesis of the local lines is the low load factor which runs 35–50% in contrast with 55–70% for the trunk lines. This lifts indirect operating costs to the point of requiring a subsidy to stay in business.

It is believed the high-speed, Model 300 would generate much higher load factors by cutting travel time between point, thus tapping the vast market dominated by the automobile. Profitable operation would then be possible within existing fare schedules.

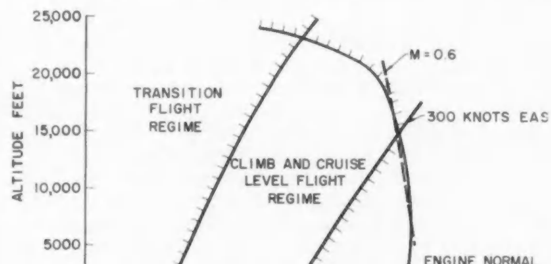


Fig. 3 — Normal climb, cruise speed, altitude capability of the Model 300, tandem-wing VTOL compares most favorably with existing local service aircraft.

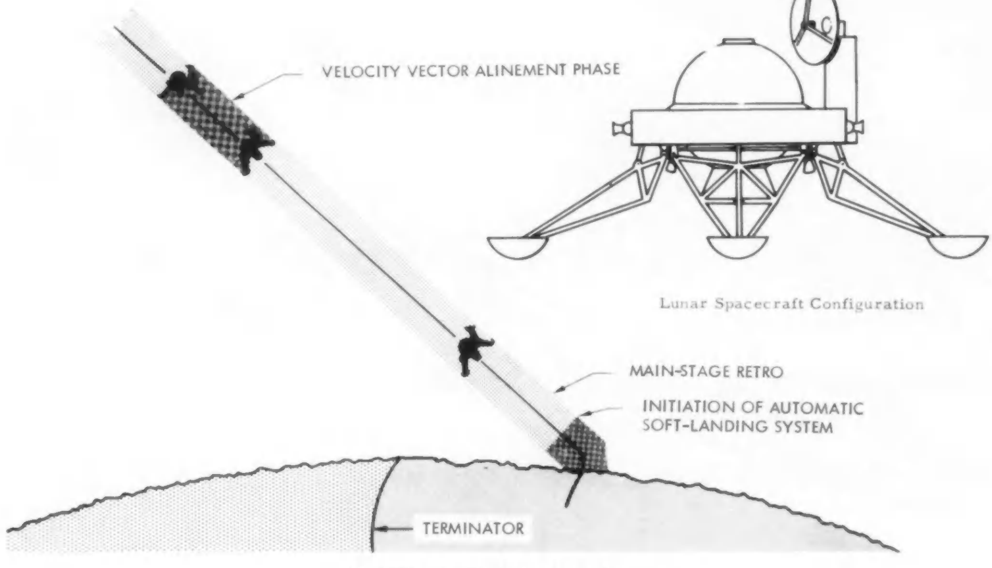


Fig. 1 — Lunar spacecraft, for which a typical configuration is shown, is to be decelerated in two stages: an uncontrolled first stage (main-stage retro) and a controlled, automatic second stage. In the second stage all residual velocities are canceled.

Landing on the Moon

SAFELY . . . SOFTLY

Based on paper by

C. M. Mears and R. L. Peterson

Missile Division, North American Aviation, Inc.

ONE plan for achieving a soft lunar landing, which was studied at North American's Missile Division, is to divide the braking maneuver into two stages: an uncontrolled first stage and a controlled, automatic, second stage. Fig. 1 illustrates this scheme.

The landing mode of the vehicle begins approximately 500 miles above the moon's surface. At this time the vehicle retrothrust axis is aligned with the velocity vector and then, over a preselected altitude range, the main stage retrorocket decreases the relative velocity between the vehicle and the moon to an acceptable level. At the end of the main retrothrust stage, an automatic landing system cancels residual velocities and maneuvers the vehicle to a touchdown on the moon. Lateral as well as vertical velocities must be counteracted by the automatic landing system in the second stage of braking.

Soft-landing with minimum energy

By letting the vehicle free-fall as far as possible, after the main retrostage is terminated, before attempting to decelerate it, the efficiency of the system is increased. This means that a minimum amount of energy would be required to brake the vehicle to a hover altitude h_c, if it were allowed to fall to the surface before retrothrust is applied. In this hypothetical case the ratio of vehicle thrust to weight (T/W) would have to be infinite, but propellant consumption would be at a minimum. Considering the more realistic situation, where T/W is limited, approximation of the ideal case is obtained by letting the vehicle fall as close to the surface as possible and then applying the maximum permissible T/W to bring it to a halt.

Although it is most desirable, from an efficiency standpoint, to use the maximum, unthrottled, T/W, throughout the second-stage braking maneuver, throttling may be required from a practical point of view due to hardware load limits.

T/W is treated as being constant for simplifying the calculations. Actually, the ratio increases as propellant is consumed, if thrust is kept constant. Thus, this assumption yields conservative values for the energy required to decelerate the space craft.

If the vehicle is allowed to free-fall after the end of the first stage of braking $\ddot{h} = -g$ is the acceleration, where g is assumed to be constant. The altitude and vertical velocity of the vehicle after a free fall of t sec, in terms of the initial conditions (condi-

The safe landing of a space vehicle on the moon will be the primary task of a lunar soft-landing system.

To accomplish this, the system must precisely control the approach energy of the spacecraft, relative to the lunar surface, so that the velocity existing at contact will not cause damage to the instrument payload, the vehicle, or the crew.

Such systems, for providing reliable and efficient landing on the moon, are currently under investigation in conjuction with the NASA program for manned lunar expeditions projected for the early 1970 period.

tions existing at the end of the main-stage operation), with no aerodynamic forces present, are:

$$h = h_0 + \dot{h}_0 t + \frac{1}{2}(-g)t^2 \qquad (1)$$

where:

h = altitude
h_0 = initial altitude
$\dot{h}_0$ = initial velocity
t = time

and

$$\dot{h} = \dot{h}_0 + (-g)t \qquad (2)$$

Eliminating t from these equations gives:

$$\dot{h}^2 = -2g\left(h - h_0 - \frac{\dot{h}_0^2}{2g}\right) \qquad (3)$$

Since e_0, the vehicle total energy per pound (potential and kinetic), at the onset of the second stage is:

$$e_0 = h_0 + \frac{\dot{h}_0^2}{2g} \qquad (4)$$

the equation of motion after substituting (4) into (3) becomes:

$$\dot{h}^2 = -2g(h - e_0) \qquad (5)$$

The trajectory of the free-fall case is illustrated in Fig. 2, where it is assumed that potential and kinetic energies are freely interchanged. The vertex of the parabola corresponds to the point where initial energy is assumed to exist entirely as potential energy. It is the height from which a body can be dropped to acquire any desired initial velocity by the time it falls to a preselected initial altitude.

To determine the vehicle trajectory during retro-thrust operation it is noted that if the given retro system, having a thrust/weight ratio T/W, can stop the vehicle at the hover altitude from the initial conditions, it would also be capable of reversing the operation and boosting the vehicle back to the initial altitude and velocity from a standstill at h_c, the hover altitude. Therefore, the curve defining the trajectory of the boost operation may be used to obtain the retro trajectory.

At the hover altitude $\dot{h}_0 = 0$ and $e_0 = h_c$. The upward acceleration during the hypothetical boosting operation is:

$$g\left(\frac{T}{W} - 1\right) \qquad (6)$$

Substituting these quantities into (5) (here the expression (6) replaces $-g$, the free-fall acceleration) yields:

$$\dot{h}^2 = 2g\left(\frac{T}{W} - 1\right)(h - h_c) \qquad (7)$$

This equation defines the boost operation and is plotted in Fig. 3. At any altitude and velocity to which the vehicle is boosted there exists a corresponding altitude and reverse velocity on the retro

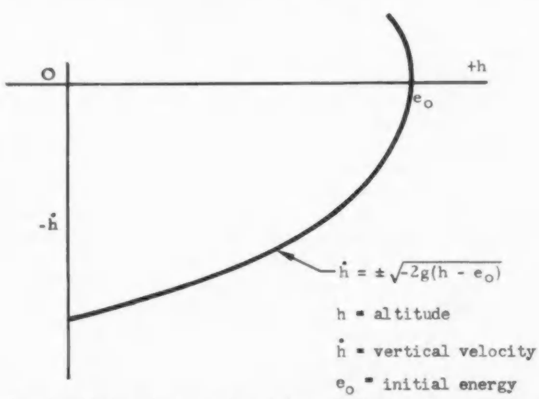


Fig. 2 — If the vehicle is allowed to free-fall after the end of the first stage of braking, its trajectory would be defined by the parabola illustrated above. In this particular case the initial energy e_0, is assumed to exist entirely as potential energy.

curve which defines the vehicle's braking capability. In this manner the retro curve is obtained as the mirror image of the boost curve.

To get a total picture of what happens after the main-stage retro action ceases, the retro curve just developed is combined with the free-fall curve, as in Fig. 4. The vehicle is allowed to accelerate from its initial condition to velocity $-\dot{h}_1$ at altitude h_1, at which point the retrorocket acts to decelerate the vehicle to zero sinking velocity at the hover altitude.

It can be seen that the vehicle may be permitted to fall closer to the surface before the point of optimum retrothrust initiation is reached, when higher values of, T/W are used.

Although an infinite T/W is theoretically the most desirable condition, there is not much to be gained by having this factor exceed 5 or 6. (If, indeed, these values can be attained). This may be shown by a plot of the impulse required to counteract a given amount of vehicle energy as a function of T/W, as drawn in Fig. 5.

In order to draw this curve it must first be recognized that the total I_T is the product of thrust T, and burning time t_B for the assumed constant-thrust retro phase. In terms of vehicle gross weight W, the impulse is:

$$\frac{I_T}{W} = \frac{Tt_B}{W} \tag{8}$$

The burning time is equal to the velocity change during retro divided by the acceleration:

$$t_B = \left| \frac{\dot{h}_1}{g\left(\frac{T}{W} - 1\right)} \right| \tag{9}$$

The value of $\dot{h}_1$, the optimum velocity for retrothrust initiation, in terms of T/W available and of vehicle energy to be countered, $(e_0 - h_c)$, is:

$$\dot{h}_1 = -\sqrt{2g\left(1 - \frac{1}{T/W}\right)(e_0 - h_c)} \tag{10}$$

This relation is developed from the fact that the total energy e_0 along a free-fall path remains constant, so that:

$$e_0 = h_1 + \frac{\dot{h}_1^2}{2g} \tag{11}$$

Solving this for h_1 and substituting into (7) gives the desired relationship, (10).

Using this value of $\dot{h}_1$ in (9) and substituting the resulting expression into (8) gives the desired vertical energy parameter:

$$\frac{\frac{I_T}{W}}{\sqrt{\frac{2(e_0 - h_c)}{g}}} = \sqrt{\frac{T/W}{\frac{T}{W} - 1}} \tag{12}$$

Lateral motion can be analyzed very simply since no gravity component exists in this direction. Therefore, the control impulse required to reduce lateral velocities to zero is directly proportional to the initial lateral velocity. The value of T/W to be used is only a function of the time available for the braking action. As a result of this, the permissible control time to counter lateral velocities is a factor which must be considered in the design of the lateral system as well as the vertical system.

Controlling vertical and lateral motion

Of the many methods which were conceived to control vertical and lateral translational motion

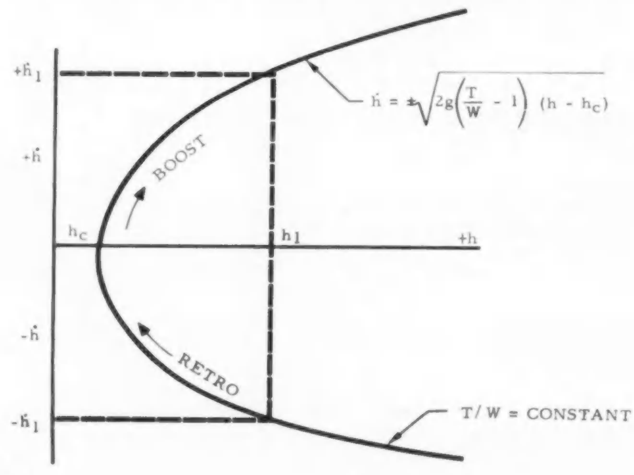


Fig. 3 — If a retro system had the capability of boosting the spacecraft from a standstill at the hover altitude h_c, upwards, it would also be able to retard the vehicle from these greater altitudes to standstill at h_c. In this manner the trajectory of the vehicle during retro is derived from the easily obtained curve defining the boost trajectory.

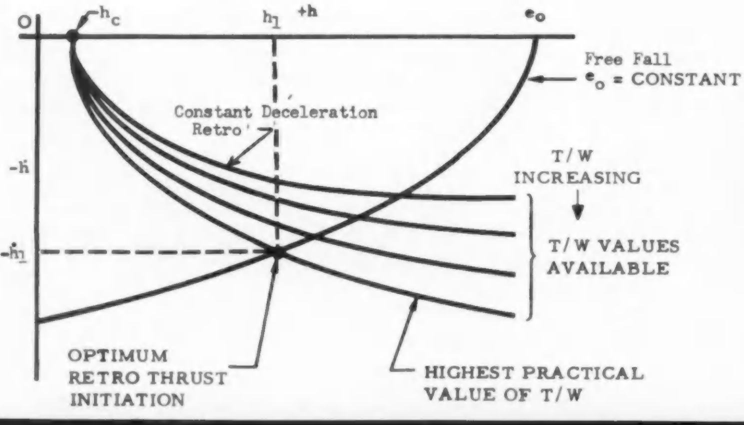


Fig. 4 — Since it is most efficient to use the largest permissible vehicle thrust/weight ratio, the vehicle is allowed to free-fall as great a distance as possible before applying retrothrust. After retro initiation, the vehicle trajectory follows the retro path defined by the value of T/W.

simultaneously, three representative techniques are:

1. Utilization of a separate propulsion systems for lateral control and for vertical control. The lateral control propulsion system can be activated as soon as the main-stage retrorocket has ceased operation and can operate continuously to hover altitude. In the vertical direction, the vehicle is allowed to free-fall until conditions of altitude and velocity are reached for which the activation of the vertical control propulsion system is optimum. From this point on the vehicle remains in a vertical attitude.

2. A single combined propulsion system used to counter vertical and lateral velocities by tilting the vehicle and permitting thrust to commence at a point such that, once it is initiated, maximum thrust is required until hover altitude is reached. Thus, only two thrust levels are utilized during retro, zero, or maximum, and lateral velocities are not canceled until it is optimum to cancel vertical velocities.

3. Use of a "90-deg kickover" technique employing a single propulsion system. Lateral velocities would be countered first by rotating the vehicle so that the thrust vector is parallel but opposite to the initial lateral velocity, and then thrusting until it is optimum to utilize maximum thrust in the vertical direction. When this optimum point is reached, the vehicle is rotated back until the thrust vector is vertical and continues in this attitude with maximum thrust until hover altitude is reached. Thus, while only one system is used to counter both vertical and lateral velocities, the canceling is not done simultaneously.

The trajectories resulting from the use of these different systems are illustrated in Figs. 6 through 8. Considering first the "separate systems" technique, represented in Fig. 6, from any selected initial altitude Δh_0, several velocities of initial vertical descent $\dot{h}_0$ may be selected. These conditions are represented by points A, B, C, D, and E.

Consider, for example, the initial condition represented by point B. Cancellation of vehicle lateral velocity commences at point B, while an attempt to counter the vertical component of velocity would not be initiated until the vehicle has free-fallen to point B′. At point B′, continuous maximum vertical thrust is commanded and the vehicle reaches point 0, the hover altitude, with no sinking velocity. The magnitude of initial lateral velocity which can be nullified depends upon the lateral T/W and the trajectory time t_T (which includes free fall from B to B′ and retro from B′ to 0). The longest trajectory elapsed time t_T occurs when the initial vertical velocity is zero, (point A,) which allows maximum free-fall time. The lateral velocity allowable at point E is a minimum since t_T is smallest for this condition.

As the initial vertical velocity component is increased the free-fall time must decrease for a constant T/W deceleration curve. At point E, no free fall is permitted and the vertical retro system must be immediately initiated to permit a successful deceleration to hover altitude. Point E, therefore, corresponds to the maximum vertical velocity that the system can counter for the given vertical T/W.

The combined systems technique is illustrated in Fig. 7. Since the thrust axis will be tilted for a portion of the trajectory (a constant tilt, θ, is assumed) there will be two retro trajectory curves. The curve from E_0 to 0 corresponds to the maximum T/W being

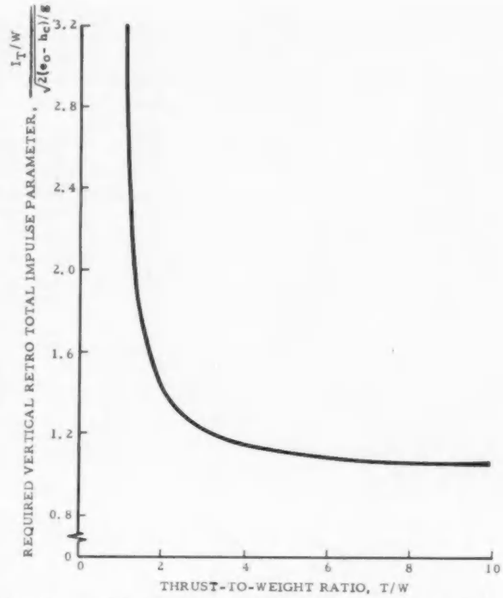


Fig. 5 — An infinite value of vehicle thrust to weight ratio is theoretically the optimum value to use. However, increasing this value beyond 5 or 6 is not worth-while because the impulse required to halt the vehicle from a given initial energy is almost constant for higher ratios.

applied in the vertical direction only, while the curve from C_0 to 0 corresponds to the vehicle being tilted throughout the retro operation, giving a maximum vertical T/W component of $(T/W)_{max}\cos\theta$.

The initial lateral velocity allowed will depend on the location of the initial vertical velocity with respect to the two trajectory representations. Thus, for an initial vertical velocity corresponding to A_0 the vehicle will free-fall to points A_1, A_2, or A_3, depending upon its initial lateral velocity. The maximum initial lateral velocity which may be countered will require that free-fall cease at A_1, at which time retrothrust is initiated and lateral and vertical velocities are canceled simultaneously during the trajectory from A_1 to 0. If the lateral velocity is zero, the vehicle will free-fall to point A_3, commence thrust, and counter the vertical velocity with no tilting of the thrust vector. For lateral velocities between these two extremes the free-fall will end at a point such as A_2 and commence thrust to cancel lateral and vertical velocities until all lateral velocities have been countered at point A_2'. At this time the thrust vector is rotated back into the vertical direction to cancel the remaining vertical velocity.

An increase in the initial vertical velocity, say to point B_0, will allow a greater maximum lateral velocity to be countered because the time from B_1, retro activation, to 0 is greater than the time from A_1 to 0. This is the effect up to point C_0 where the initial lateral and vertical velocities are countered by immediate application of maximum thrust at the angle θ, with no period of free-fall. Beyond point C_0 (for example, point D_0) less time is available to counter lateral velocity, so that initial lateral velocities allowed must be reduced. The locus from D_0 to D_1 represents an acceleration $(T/W)_{max}\cos\theta$; that is, the vehicle is tilted and the lateral velocity is canceled from D_0 to D_1. At this time the vehicle must

rotate to 0-deg pitch and cancel the remaining vertical velocity to accomplish hover successfully with the $(T/W)_{max}$ available. At point E_0, no initial lateral velocity is permissible because all thrust is required in the vertical direction to counter the vertical velocity successfully.

The characteristics of the 90-deg kickover retro technique can be developed from Fig. 8. For any of the initial conditions A, B, C, D, and E, the 90-deg kickover commences with a 90-deg pitch rotation in the proper direction to cancel the existing lateral velocity. The retro is immediately fired while the vehicle free-falls to a point on the retro curve, such as B′, at which time the thrust axis is rotated to 0 deg to cancel the vertical velocity component and retro deceleration proceeds from B′ to the hover altitude represented by point 0.

The magnitude of lateral velocity which can be nullified depends upon the available T/W and the permissible free-fall time. Thus, at point E no initial lateral velocity is allowed.

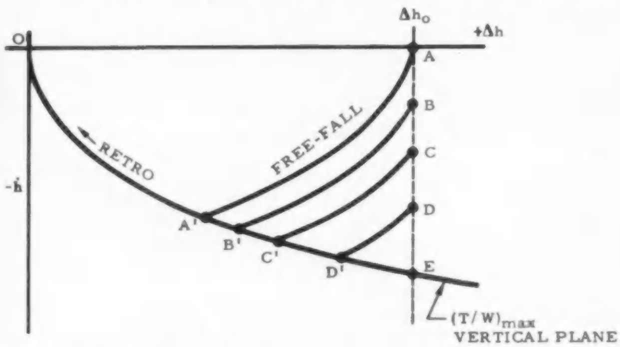


Fig. 6 — Trajectory control using separate lateral and vertical retro systems is illustrated. The lateral control system is operative over the entire period following the main-stage retro, but the vertical retro is activated only at the times corresponding to the intersections of the free-fall (corresponding to different initial conditions) curves with the retro curve (such as A′ or B′).

Practical thrust control

Practical means of controlling the descent of the vehicle, within the framework of the minimum energy retro concept, were also studied. Of the methods conceived for generating control commands to the retro system, two that appeared to be promising are:

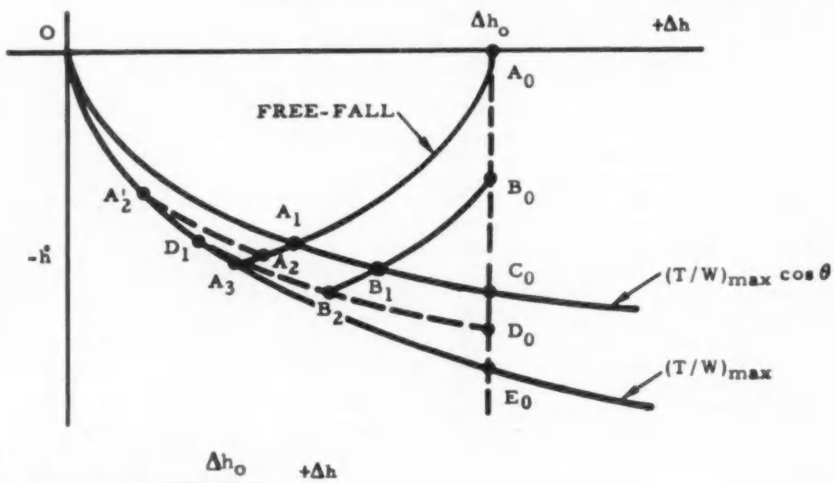
1. Programed flare — In this system the sinking speed commands are programed as a function of altitude above the terrain. Only when the sinking speed exceeds the instantaneous programed value at a particular altitude is an attempt made to control this speed.

2. Command hover — This system functions similarly to the programed flare technique except that altitude error and altitude rate are used to generate control commands. Thus, the sinking speed programer is eliminated.

Control commands emanating from either of these systems can be used to modulate retro thrust by: (a) proportional variation of thrust levels (thrust amplitude modulation) and (b) time variation of constant thrust levels (impulse modulation).

To Order Paper No. 302B . . .
from which material for this article was drawn, see p. 6.

Fig. 7 — Combined Systems Technique — The $(T/W)_{max}\cos\theta$ curve is the effective vertical retro, while the vehicle is tilted for the purpose of canceling lateral thrust. For initial conditions corresponding to C_0 the maximum lateral velocity can be canceled and the vehicle remains tilted throughout the second-stage retro. At E_0 no lateral velocity can be canceled since the vehicle may not be tilted if the vertical velocity is to be successfully counteracted.



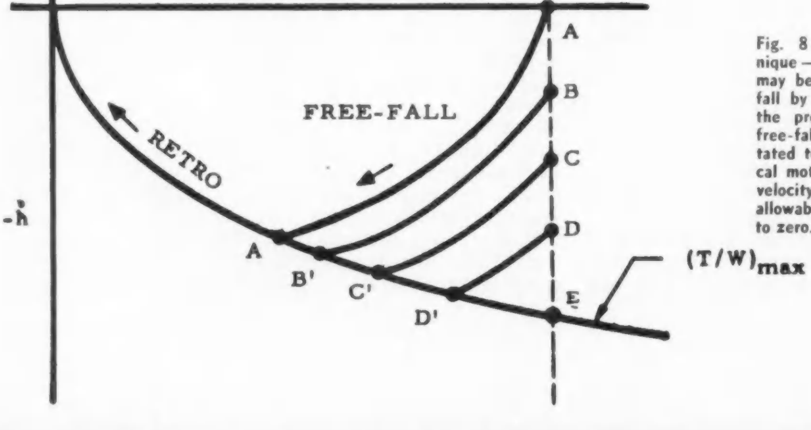


Fig. 8 — 90-deg Kickover Technique — The initial lateral velocity may be canceled during the free-fall by a 90-deg pitch rotation in the proper direction. After the free-fall period the vehicle is rotated to 0 deg to brake the vertical motion. As the initial vertical velocity increases from A to E, the allowable lateral velocity is reduced to zero.

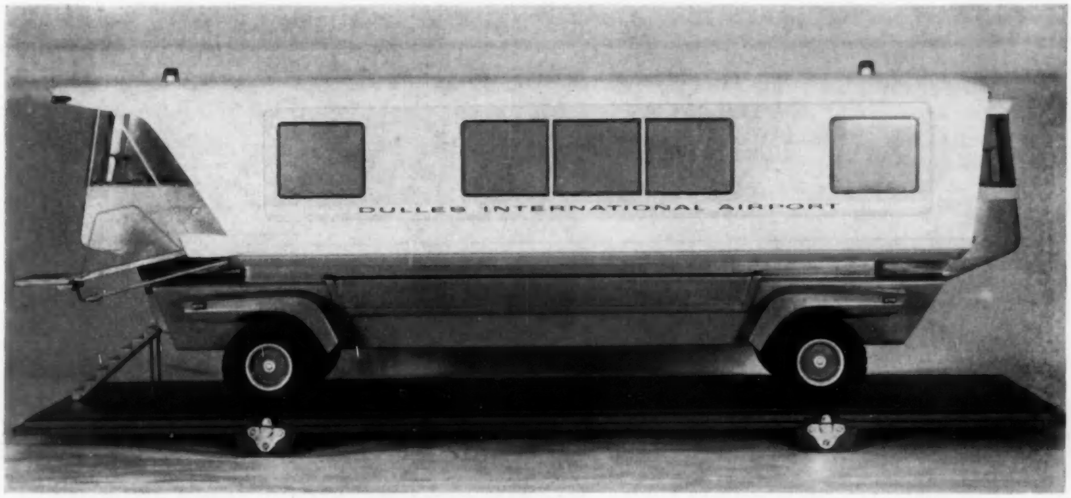


Fig. 1 — Mobile lounge being developed for transfer of passengers to and from jet transports will revolutionize airport design by doing away with terminal "finger-like" construction.

Mobile lounge to speed passenger-handling at airport

Based on paper by

J. M. Martin

Chrysler Corp.

A ROOM on wheels, 60 ft long, 15 ft wide, and seating 90, is being developed for transfer of passengers to and from jets at the new Dulles International Airport. A preliminary concept of the vehicle is shown in Fig. 1.

A fleet of these lounges will operate from a central terminal and eliminate almost all of the cross-country hiking now required of people who want to fly. Passengers will be comfortable and under cover at all times, and the system will minimize aircraft taxiing and eliminate the need for precise positioning. It will also make possible divorcing passenger-handling from operating facilities and reduce the large capital expenditure for inflexible facilities.

Problems of design

The lounge will have drive controls and passenger entrances at both ends. One end will mate with the terminal building so that passengers can enter two abreast; the other end will mate with the aircraft so that passengers can board through the fuselage door opening.

Studies have shown a vertical adjustment of about 8 ft to be necessary to accommodate various types of aircraft. This vertical adjustment coupled with aircraft matching has been a major problem. The solution has had to meet the requirements for range of elevation, maintenance of a platform at the aircraft parallel to the body floor, adequate and accurate controls to ensure quick, positive positioning, suitable devices for matching to integral stairways with railing, maintenance of a maximum slope of 1/6, two accesses on a single ramp, and weather protection. As now designed, the lounge will serve all 4-engined aircraft in use or on order for international flights, but will not handle the smaller Douglas DC-3, Fairchild E-27, Martin 202, or Convair 240.

The lounge will be powered by a conventional engine and be capable of a maximum cruising speed of 30 mph. It will have self-contained heating and airconditioning systems. The driver will be seated at the lounge body level, close to the passengers and to the transition device, where he will have good visibility.

The lounge is more of a monster than Fig. 1 indicates. It is roughly the size of two city buses parked side by side with two more directly behind and four more on top of the first four. Every effort is being made to give it distinctive styling and avoid any resemblance to a bus or railroad coach.

To Order Paper No. 283A . . .
from which material for this article was drawn, see p. 6.

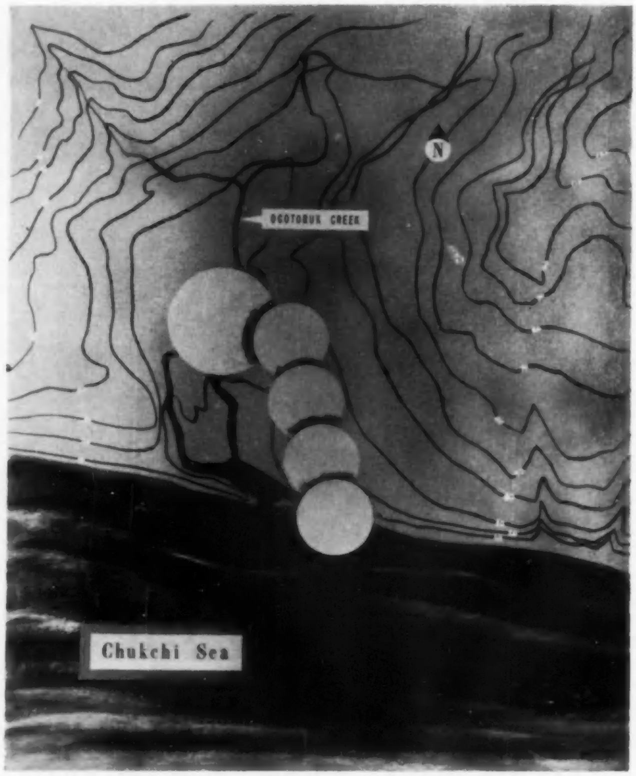


Fig. 1 — **Proposed layout** of explosives for the Chariot Project.

Big BLAST Set for Alaska

Cape Thompson site chosen for nuclear earthmoving tests

Based on paper by

Gerald W. Johnson

University of California

BEFORE nuclear excavation of harbors, canals, strip mines, and flood control reservoirs can become a reality, additional data will be needed on large-yield nuclear cratering detonations and on simultaneous detonations of lines of charges, particularly from a radioactivity distribution viewpoint. Cape Thompson, on the northwest coast of Alaska, will act as test site for large-scale nuclear excavations releasing limited radioactivity to the atmosphere. This experiment may prove to be the forerunner of nuclear earthmoving projects near populated regions.

Detonation plan

As presently planned, four 20-kiloton nuclear explosions and one 200-kiloton nuclear explosion, placed at optimum depths for cratering and containment of radioactivity, will be detonated simultaneously to produce a single crater which will have the approximate configuration of a small harbor. The proposed detonation layout is shown in Fig. 1.

Test objectives

The primary objectives of this experiment (Project Chariot) are to:

1. Obtain data on the distribution of radioactivity deposited in the area of the crater and released to the atmosphere for nuclear explosions at depths producing crater diameters.
2. Evaluate the effects of radioactivity, blast, ground shock, and throwout on the local biology.
3. Gain data on nuclear cratering for a different medium, at higher yields, and on the effects of simultaneous multiple detonations.
4. Increase the knowledge of air-blast pressures

and seismic disturbances versus distance from nuclear cratering detonations for deeply buried cratering explosions.

Need for tests

That such an experiment is critically necessary is apparent when it is noted that the only reliable nuclear cratering data available at present are for 1.2-kiloton explosions in alluvial fill at the Nevada Test Site. Project Chariot has been designed to extend this knowledge to yields more consistent with excavation projects of appropriate magnitude. In addition, Chariot will give important data on the gains to be derived from simultaneous detonation of a line of nuclear explosives.

The amount of radioactivity released to the atmosphere by nuclear cratering detonations varies strongly with depth of burst. Based on a 115-ton explosion (Neptune) in Nevada, it appears possible to excavate almost a maximum volume with only 1–2% of the gross radioactivity escaping to the surface. In Project Chariot, for which similar scaled depths of burial will be used, it is planned to measure the overall distribution of radioactivity in the "fall-back" material in the crater, on the surface in the vicinity of the crater, on the surface within 100 miles, and in the atmosphere. It is not expected that there will be any detectable contribution to worldwide activity.

In addition, a thorough survey of biological and ecological effects is being made under the auspices of the AEC Division of Biology and Medicine. One aspect of the biological program is directed toward the determination of the most favorable factors to minimize the biological cost, such as time of year and direction of fallout. If, in the judgement of the group reviewing the experiment, the conditions can be specified under which the experiment can be safely conducted, authority to proceed will be requested. Because of the extensive ecological program carried out to determine the possible biological consequences of the shots, much will be learned about the combined long-range effects of the detonation on the plant and animal life in the area.

During the summer of 1959, preliminary site surveys were completed, including geological, meteorological, ecological, and oceanographic. More work was completed during 1960. The work will continue so long as it provides substantial new information.

Following the Chariot experiment, it will be necessary to set up additional experiments to learn about cratering and radioactivity distribution in other kinds of rock. Concurrently, the development of special explosives to minimize cost and reduce radioactivity also should be pursued. Assuming success in all of these experiments, it can be anticipated that appropriate excavation projects could be taken soon after.

FOR THE PAST THREE YEARS . . .

. . . the Atomic Energy Commission and its contractors have been considering the practicability of carrying out large-scale excavation projects using nuclear explosives.

This article discusses the proposed large-scale nuclear excavation experiment at Cape Thompson, Alaska.

To Order Paper No. 301A . . .
from which material for this article was drawn, see p. 6.

THE SOVIET UNION has been using massive charges of chemical explosives for excavation for several years and is expanding its activities.

Timetable of Soviet Massive Industrial Explosions

Location	Date	Charge (tons)	Purpose
Lan'chou, China	July 19, 1956	1640	Overburden removal for the opening of the Bayinchansk copper ore deposit.
	Nov. 16, 1956	4780	
	Dec. 31, 1956	9200	
	(The last explosion removed 2,000,000 cu m and crushed 7,000,000 cu m. The pit formed was to provide for open pit mining.)		
Tagansay (Near Tashkent)	Dec. 19, 1957	1000	Experiment in cratering. Material was dry clay. Center of charge at depth of 133 ft. Volume excavated 740,000 cu yd. Useful as water reservoir.
Sverdlovsk	March 25, 1958	3200	Diversion of the Kolonga River from rich iron ore deposits. Trench formed was 1300 yd long, 100 yd wide, and 28 yd deep.
	Announced Plans		
Alma Ata	1960	700	Cause landslide to make earth dam.
	1961	2500	
Yakutsk	?	40,000	Overburden removal from coking coal deposit.
Angara River	Late 1959 (Not executed)	30,000	Large-scale underwater blasting to widen river in reservoir project.

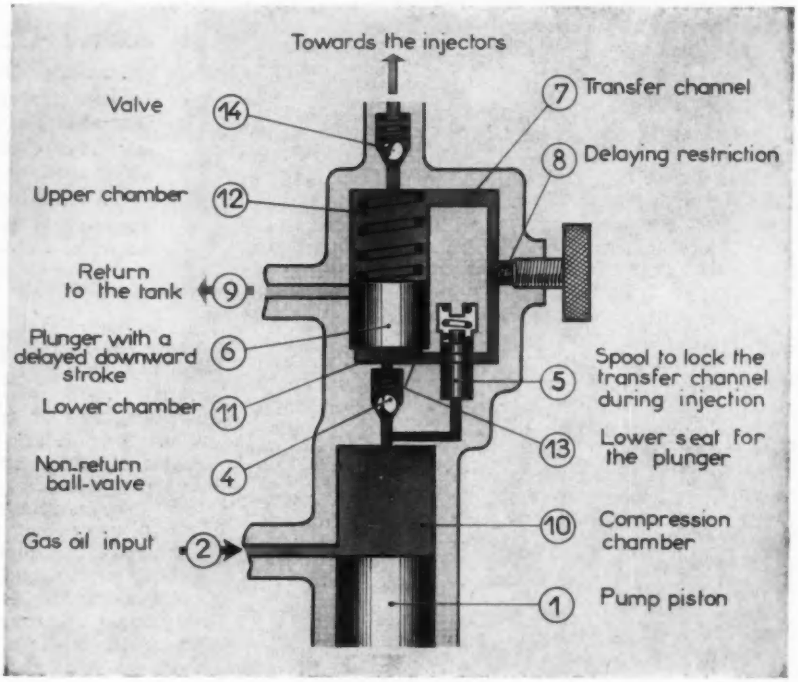


Fig. 1 — "Liquid stop" governor of the "Silto" pump. This governor is self-adjusting, as it will maintain a constant fuel flow at any equilibrium operating point. The heart of the governor is the "liquid stop," which accurately determines the displacement of the shuttle. As long as the stop is in one position, the volume of fuel forced out by the shuttle is fixed.

"Liquid Stop" Governs Diesels

Based on paper by

Pierre E. Bessière

Précision Méchanique Labinal (France)

A "LIQUID STOP" governor is the unique feature of a newly developed, single piston, diesel-engine fuel distributor pump (the "Silto" pump). The major advantage of this system is that it is self-adjusting. At a constant engine speed the volume of fuel delivered to the engine will also be held constant. Should a change in load cause the engine speed to change, equilibrium is reestablished at a different, but constant, fuel flow.

The operation of the "liquid stop" governor can be explained using Fig. 1. Fuel delivered by the pump is introduced to the chamber (10) above the cam driven plunger (1). The upward stroke of the plunger forces the fuel into the governor where some of it is bypassed back to the tank through (9), and the rest delivered to the engine through the outlet check-valve (14).

The increasing pressure in chamber (10) acts to lift the locking valve (5) first, and then the ball-valve (4). This sequence is ensured by the harder spring above the ball valve. The locking valve serves to block the transfer duct (7). With this duct blocked, the fuel passing through the ball check-valve forces the shuttle (6) upward until the return port is uncovered. The fuel then flows back to the tank.

When the plunger moves downward the locking valve opens and the ball-valve closes. The shuttle, under pressure by the return spring, returns to its seat, thus forcing the remaining fuel through the transfer duct and into the shuttle upper chamber. The next upward stroke of the plunger causes the cycle to be repeated. However, now, the upward stroke of the shuttle causes the fuel above the shuttle to be ejected and sent to the injector.

Fuel flow is varied by adjusting the needle-screw. This screw can be used to adjust the area of the duct to slow the descent of the shuttle so that the plunger begins to rise before the shuttle is seated. The shuttle then seats itself on the fuel jet flowing through the ball check-valve. This phenomenon is the reason why the system is called "liquid stop." The accuracy of the "liquid stop" is such that, between any two successive injections, the shuttle returns to its previous position to within one hundredth of a millimeter. The higher up the "liquid stop" occurs, as determined by engine speed (reflected in the frequency of the plunger stroke), and needle-screw setting, the smaller will be the shuttle stroke and hence the fuel output.

To Order Paper No. 296B . . .
from which material for this article was drawn, see p. 6.

Radiation Protection Hinges on Detection Tools

Based on report by secretary

R. K. VANCE

North American Aviation, Inc.

SINCE there is no human sensory organ to detect radioactivity, adequate instrumentation is necessary in all areas where the possibility of radioactive exposure exists.

The basic principles of radiation protection involve the three factors of shielding, distance, and time. In addition, a carefully planned educational program is necessary in plants using radioactive materials so that employees' fears can be reduced and increased confidence can be instilled in the people concerned with radioactive materials handling.

Four of the common symptoms of cell damage due to radiation exposure are:

1. Skin burn due to soft beta radiation (arathema).
2. Loss of hair (epillation).
3. Damage to blood-forming organs resulting in high white blood cell count (leukemia).
4. Cataracts of the eye caused by excessive exposure to neutrons.

SERVING on the panel which developed the information in this article, in addition to the panel secretary, were: chairman **H. G. Henry**, North American Aviation, Inc.; co-chairman **J. C. Lang**, North American Aviation, Inc.; **J. Rogers**, Division of Occupational Health, City of Los Angeles; **J. Day**, Albert C. Martin & Associates; **R. H. Beight**, North American Aviation, Inc.; **M. G. Eggert**, Holladay & Westcott; and **C. B. McKee**, General Electric Co.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.)

Compact Turbine Uses Hybrid Compressor

Based on paper by

C. J. RAHNKE and R. H. CARMODY

Continental Aviation and Engineering Corp.

A COMPRESSOR arrangement configuration recently developed in the quest for higher pressure ratios in small engine compressors is a transonic axial stage combined with a centrifugal stage. Experience with these compressors has indicated that pressure ratios of 5.0/1 to 6.0/1 can be achieved with reasonable efficiencies.

Since the bulk of the pressure rise takes place in the centrifugal stage the performance is largely determined by the efficiency of this stage. This is apparent when it is realized that over 75% of the work is done there in a typical combination compressor having a 5.5/1 overall pressure ratio, with a 1.6 transonic axial stage.

A typical arrangement for this type of compressor is seen in **Fig. 1**. It can be seen that the flow from the axial stage must be brought radially inward to the inducer of the centrifugal stage. The transition section where this deflection takes place is a critical area in the design. If the flow entering the inducer is highly distorted a large performance loss will result in the centrifugal stage. This is a serious matter since the performance here is so influential in the overall operation. Careful attention to details and good aerodynamic design are essential in the transition section. The inward turning flow has a tendency to separate from the inner wall of this section. The ensuing flow distortions are highly detrimental and must be avoided.

Another critical aspect of the compressor is the part speed matching of the stages to insure surge-free operation. It has been found that if the axial stage has an insufficient part speed surge margin it may trigger the centrifugal stage into a premature surge. This problem takes on larger proportions as the axial stage pressure ratio is raised. At present the peak efficiency of the transonic axial stage is compromised slightly to assure a broader range.

■ **To Order Paper No. 268D . . .** from which material for this article was drawn, see p. 6.)

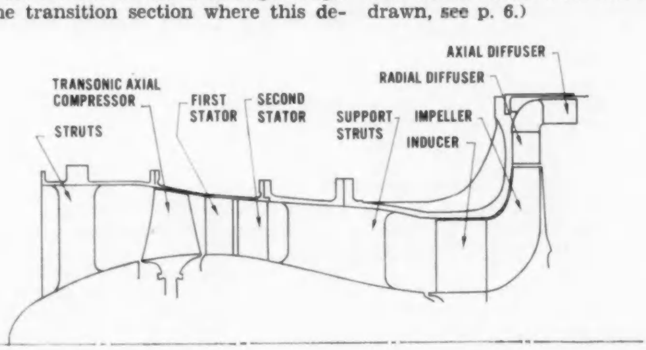


Fig. 1 — Typical transonic axial and centrifugal stage compressor. The transition section between the two stages is a critical area. Although aerodynamic considerations are important here, the length and shape of this section are fixed by the bearing package size and the arrangement of the accessories wrapped about it.

Tests Show Strength-Ductility Relationship of Refractories

Based on report by secretary

I. L. SCHWARTZ

Marquardt Corp.

STUDIES of the relation between material condition and properties affecting the formability of molybdenum indicate that cold worked structures have the highest strength and lowest ductility. Columbium, tantalum, and their alloys possess good formability, but are lower in strength than molybdenum.

Stress relieved molybdenum is lower in strength than the cold-worked material, but has somewhat better ductility. A recrystallized material provides good ductility, but still lower strength. This latter condition, however, can result in very poor properties if constituents are precipitated at the grain boundaries during recrystallization and grain growth.

Though cold-worked molybdenum produces the highest strength, it is not the best treatment for good all-around properties because it is most susceptible to early recrystallization at high service temperatures. Columbium, tantalum, and their alloys show less tendency to work harden, so that the gain in strength through cold work is small.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were chairman **J. W. Chambers**, Marquardt; **H. Smallen**, Northrop; **Verne Pulsifer**, Fansteel Metallurgical; **D. W. Kraybill**, Chance Vought; **E. E. Weismantel**, The Budd Co.; **R. W. Hansen**, Boeing; and **G. C. Irons**, Marquardt.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.)

Simulation Solving Industrial Problems

Based on report by secretary

H. F. MURRAY

Douglas Aircraft — Santa Monica

SIMULATION is giving industry the ability to project probable results from a series of alternatives. This aid to decision making is a part of a relatively new science which provides a quantitive analysis to executives for management decisions. Simulation is not concerned with marginal improvement. Rather, it is concerned with major or even revolutionary improvements.

Typical of the important problems in industry being resolved by simulation are:

1. Setting up production schedules which take delays into account.
2. Scheduling repair and preventive maintenance programs.
3. Establishing spare parts inventory.
4. Balancing inputs and outputs affected by product mixes.
5. Sequencing work loads.
6. Choosing numbers of machine operations and manloading.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: Chairman **S. J. Sullivan**, Douglas-Santa Monica; **C. A. Shadle**, Lockheed; **D. J. Thornton**, Rohr Aircraft; **J. F. Considine**, Ryan Aeronautical; **R. M. Wrestler**, Norair Division, Northrop; and **D. D. Farguson**, North American Aviation.

(This article is based on a report of one of 14 aerospace manufacturing forum panels. All 14 are available as a package as SP-333. See order blank on p. 6.)

Fuel, Hard Cranking Relationships Studied

Based on paper by

R. S. SPINDT and

D. R. O'MALLEY

Gulf Research & Development Co.

RECENT studies of abnormal combustion at engine cranking speeds indicate that the preflame reaction behavior of fuels affects the hard-cranking characteristics of an engine. Pressure records give evidence for these reactions, accompanied either by degenerate explosions and/or autoignition. Speed records and crank-angle-position marks indicate the changing physical environment with time.

Some fuels in this study gave evidence of degenerate explosions. When this occurred, it was usually present in all cycles that showed abnormalities. Not all fuels autoignited. But when they did, the autoignition was usually quite consistent. Autoignition may occur without starting knock, it was shown.

Poor test-to-test and cycle-to-cycle reproducibility experienced in these tests run with a multicylinder engine suggest to Gulf researchers that evaluation of fuels for hard cranking resistance might be done more accurately in a single-cylinder unit.

■ **To Order Paper No. 293B . . .**
from which material for this article was drawn, see p. 6.

New Vibration-Resistant Battery Uses Resin Bond

Based on paper by

R. L. BENNETT

Electric Autolite Co.

A NEW LEAD-ACID BATTERY construction, aimed at eliminating battery failures due to vibration, uses resin to cement together the container, the plates, and the separators along the plate that rests in the lower part of each cell. This firm anchoring of plates and separators to the container is made possible by recent developments in thermosetting resins. The integral bond insures that the plates and separators can vibrate only at the same rate as the container. Thus, the whole battery functions as a strong, vibration-resistant unit.

The bonding agent used may be any compound which is resistant to chemical attack in the battery system; is a nonconductor of electricity; and will produce a strong and rigid joining of the parts. Included among suitable materials are thermosetting resins of the epoxy, furfural, or phenolic type.

Six test batteries of this new type are still performing satisfactorily after 24 mo of service on government-operated bulldozers. Similar batteries of standard construction had previously been failing within 9 mo due to vibration damage.

(Material in this article is drawn from one of 12 papers included in SAE Technical Progress Series, Volume 3: Storage Battery Symposium — 1961. To order this publication, TPS-3, see p. 6.)

No Zero Shift

Based on paper by

SHIN MATSUOKO

Tokyo Institute of Technology

THE catenary diaphragm aircooled strain-gage indicator developed by C. S. Draper and T. Y. Li has been improved and a water-cooled version developed. By covering the strain-generating tube with a triple-purpose rubber tube of high insulation, both stabilization and improved performance have been achieved.

Fig. 1 shows aircooled model MPER-LV, with an aluminum cylinder to reduce heat radiation.

Fig. 2 is water-cooled model MPER-MV, with the water path as shown in Fig. 3. Two fins made of synthetic rubber are attached on the surface of the strain gage. Water from the inlet is forced through the hottest part, that is, through the inside of the nut thread and the inner side of the diaphragm. It makes its exit from the outlet at the opposite side. It cools both sides of the gage, thus raising gage voltages and, consequently, its output power. Several bypass holes are located in the upper side, to prevent accumulation of bubbles.

In both models, the diaphragm is connected by double nuts, with a diameter of 2 mm to the strain-generating tube to prevent their separation.

To calibrate the pressure indicator accurately, it is desirable that the surface area and number of bends be as small as possible. This increases accuracy and keeps the gage free from capacitor factor and electric noise. To meet these requirements, however, would mean a decrease of resistance and a corresponding lowering of gage voltage that can be applied and, hence, a smaller output. This, in turn, causes difficulty in the amplification system. Therefore, some compromise must be made.

With a 240-ohm, 4-gage system, satisfactory measurements have been made on high-frequency waves with small amplitude, caused by knocking and other phenomena, by applying 20–30 v. Experience indicates that this is the desirable compromise point. To increase output, a 1000-ohm, 2-gage system was used in model LV.

The receiving diaphragm has a catenary shape, similar to that on the Draper-Li gage.

When the distance between the support points of the catenary receiving diaphragm is increased, and gradually approaches the inner diameter of the

Featured on New Strain-Gage Engine Indicator

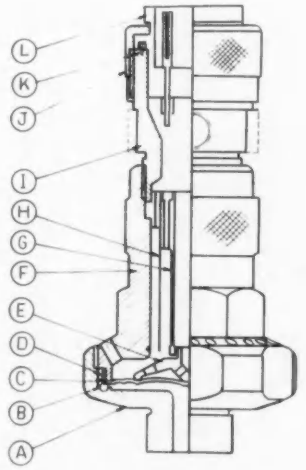


Fig. 1 — Aircooled model LV strain-gage-type indicator. *A* — gas intake support, *B* — gasket ring, *C* — diaphragm, *D* — ring, *E* — float preventer, *F* — body, *G* — strain generating tube, *H* — aluminum insulator, *I* — strain tube support, *J*, *K*, *L* — connector lead supports.

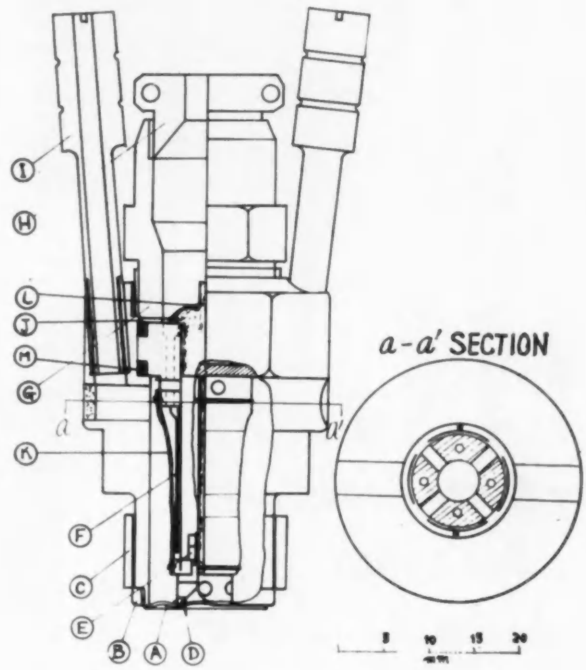


Fig. 2 — Water-cooled model MV strain-gage-type indicator. *A* — catenary diaphragm, *B* — ring, *C* — 18-mm thread (P = 1.5), *D* — float preventer, *E* — connector nut, *F* — strain generating tube, *G* — strain tube support, *H* — connector lead support, *I* — water intake tube, *J* — sealing ring, *K* — rubber tube, *L* — blind stop.

diaphragm, the efficient area ratio will increase, as will the input force of the diaphragm, if the diameter is the same. Conversely, the temperature characteristics and the dynamic temperature characteristics will greatly worsen, and the zero shift will increase.

The stress distribution of the pressure receiver diaphragm becomes very uneven, causing early breakage in the center.

If the damping characteristics are measured when the strain-generating tube is noncoated, its damping ratio is found to be extremely high. This counteracts the efforts of giving a high natural frequency to the tube, and results in a slight improvement in frequency characteristic. The butyl rubber tube covering the strain tube acts as a damper as well as insulation and cooler.

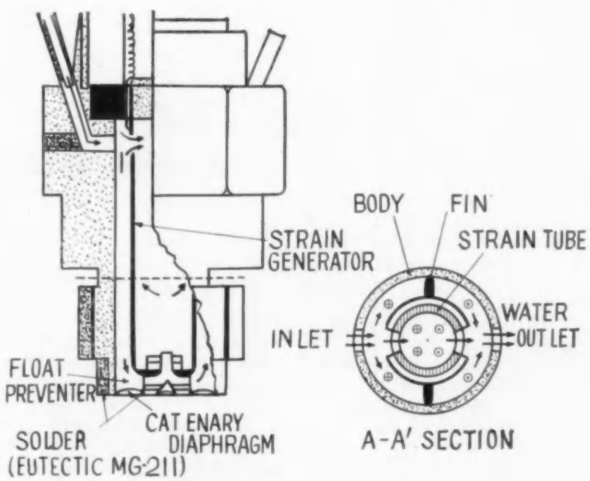
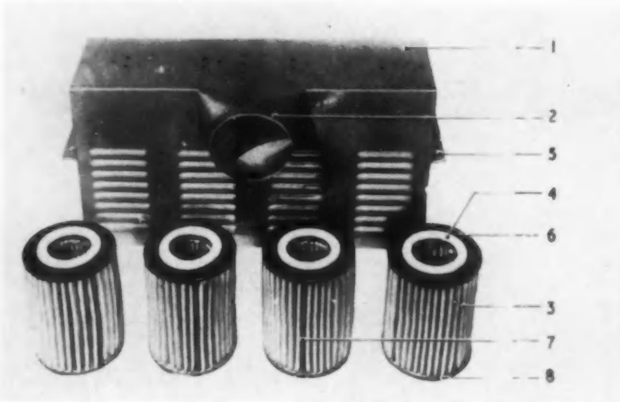


Fig. 3 — Schematic diagram of model MV, showing water path.

■ To Order Paper No. T48 . . .
from which material for this article was drawn, see p. 6.



No.	DESCRIPTION
1	MANIFOLD ASSEMBLY
2	5 in. DIAM. OUTLET
3	FELT & MESH
4	SEALING FELT
5	MOUNTING BRACKETS
6	TOP PANEL
7	FIXING RODS
8	BOTTOM PANEL

Fig. 1 — Filter elements and manifold assembly for air cleaner used on 150-bhp engine.

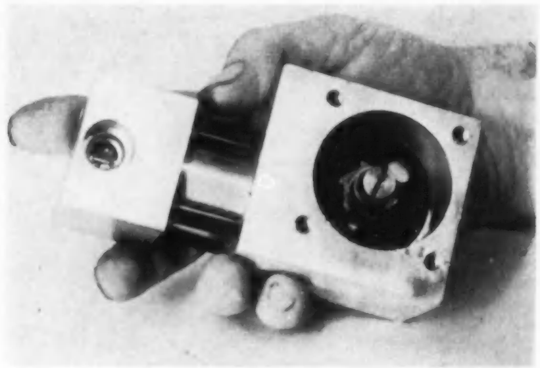


Fig. 2 — Filter cleaning mechanism is so small it fits in the palm of the hand. It is simple, inexpensive, reliable, has few parts, and is capable of inexpensive mass production.

Very Dusty Conditions Don't Faze This Engine Air Cleaner

Based on paper by

LT.-COL. GEORGE L. A. COATES and ERIC V. TULL

Military Engineering Experimental Establishment, War Department (England)

FOR earthmoving equipment operating under extremely dusty conditions — like those sometimes encountered in South America, Australia, Africa, and India — a self-cleaning air cleaner has been developed, as shown in Fig. 1.

The air needed for blowing the dust from the air cleaner comes from the small compressor usually found on earthmoving equipment for power-steering, braking, and the like.

The filter is designed to clean itself every 4 min by discharging an air bottle of about ½ cu ft of air at 80-psi pressure through each of the filter elements in a reverse direction, in turn, at 1-min intervals. The recharging of the air bottle through a finely filtered orifice determines the cleaning frequency. This timing can be lengthened or shortened according to the diameter of the orifice and the capacity of the air bottle.

The effect of the sudden blast of air passing from inside to outside the filter element wall releases the dust that has accumulated on the external wall, so that it falls clear of the filter into the open atmosphere.

The entire cleaning mechanism for engines up to 500 hp can be held in the palm of the hand, as shown in Fig. 2.

■ **To Order Paper No. 305B . . .**
from which material for this article was drawn, see p. 6.

Individual Build Can Cut Assembly Costs

Based on paper by

P. W. HOUSE

Delco-Remy Division, General Motors Corp.

INDIVIDUAL build calls for one operator to assemble a unit from start to finish rather than to perform a single function on a progressive assembly line. As a method it is as old as assembly itself, but it is particularly well-suited where the production is low, or there are miscellaneous models, or service assemblies.

Individual build eliminates the uneven distribution of work which often develops when dividing an assembly line into multiple operations along a moving belt. With a number of operators assembling similar parts, a change in schedule can be made in increments without affecting efficiency. If one operator is absent, others are undisturbed.

The method allows parts to be used which are within print limits but not within required tolerance for automatic feeding. Moreover, it works well in conjunction with a progressive line as a work station for surplus operators for small run jobs. And several models can be run simultaneously.

Care must be taken to arrange the work place layout and to provide ample stock supply. To do this effectively, it is necessary that a number of assemblies be built in a segregated area where any required changes can be made and evaluated. The operator must be well trained by competent methods-minded people. Work standards for the assembly must be established and maintained in accordance with the data recorded during development. Once the job is placed on the production floor, close supervision is required until all operators are meeting the specified daily production.

■ **To Order Paper No. 328A . . .**
from which material for this article was drawn, see p. 6.

SAE NEWS

A report from the BOARD OF DIRECTORS

At the January 13, 1961, meeting of the Board of Directors, the following actions were taken:

APPROVED

TWIN CITY SECTION TERRITORY extension (**Summary 1**)

WESTERN MICHIGAN SECTION TERRITORY extension (**Summary 1**)

SECTION status for **COLORADO** Group (**Summary 2**)

STUDENT BRANCH at California State Polytechnic College at Pomona (**Summary 3**)

WRITE OFF of small uncollectible items (**Summary 4**)

AUTHORIZATION OF SIGNATURES for Clarkson and Springer Award Fund Bank Accounts (**Summary 4**)

Proposed Amendment to Constitution on Definition of **ASSOCIATE GRADE** (**Summary 5**)

By-Law amendment **INCREASING SIZE** of Finance Committee (**Summary 6**)

San Francisco State College approved for **SAE STUDENT ENROLLMENT** (**Summary 8**)

Election to **SAE MEMBERSHIP** of 133 applicants (**Summary 8**)

TRANSFER IN GRADE of six members (**Summary 8**)

FRANK W. FINK to fill vacancy on 1961 Board of Directors (**Summary 9**)

SECURITY CLEARANCE resolution (**Summary 10**)

President Kucher's 1961 **COMMITTEE PERSONNEL** appointments (**Summary 8**)

Board of Directors' **EXECUTIVE COMMITTEE** personnel (**Summary 8**)

TECHNICAL COMMITTEE REPORTS for period December 1, 1959, to December 1, 1960 (**Summary 8**)

CONFIRMED

Action taken on ballot on **ASA DIRECTORS** (**Summary 7**)

REJECTED

Twenty-four applicants for **MEMBERSHIP** (**Summary 8**)

Two requests for **TRANSFER IN GRADE** of membership (**Summary 8**)

1

Extension of Section Territory

1960 Sections Board Chairman, W. F. Ford, reported that the Sections Board, after considerable study and review with the Sections involved, recommended the extension of the territory of the following two Sections:

(a) Twin City Section to include all Minnesota counties not now included, Douglas County in Wisconsin, six counties in North Dakota and seven counties in South Dakota.

(b) Western Michigan Section Territory to include eight counties in Michigan.

The Directors approved the extension of the Section territories as noted above.

2

Section Status For Colorado Group

Acting upon the recommendations of the Sections Board, the Directors approved the request of the members of the Colorado Group that it be elevated to the status of Section. The Sections Board reported that its recommendation grew out of the knowledge that the Group's membership and meetings have strengthened in recent years. Further, the composition of the Group's membership more than satisfies the requirements for Section Status.

The new Colorado Section had been a Group since April, 1943. Prior to that, it was known as the SAE Club of Colorado. Members in the area held meetings a number of years even before they were officially recognized as a Club by SAE Council.

3

New Student Branch in California

The Directors approved the Sections Board recommendation that a Student Branch Charter be granted to the SAE Student Group at California State Polytechnic College, Kellogg Voorhis Campus, at Pomona, California. It was reported to the Directors that this Group has been organized for more than a year. Members of the SAE Southern California Section advised that the students in the Group have done a fine job in this period and that they have had active support and encouragement from the faculty. These men feel the new Student Branch will be a credit to the Society.

"A summary report of the actions of the Board of Directors shall be published in the next following issue of the official publication of the Society."
. . . from C 6 of the SAE Constitution.

4

Financial Matters

As recommended by the Finance Committee, the Directors approved the following items:

(a) That $548.10 in small uncollectible items be written off the books of account.

(b) That the signatures of the Secretary and General Manager, Assistant to the General Manager; Manager, Administrative Division be authorized on the Coker F. Clarkson Fund and the Russell S. Springer Award Fund Accounts at the Union Dime Savings Bank of New York.

5

Proposed Amendment of SAE Constitution

The Directors accepted the Membership Grading Committee's recommendation that the necessary steps be taken to restate C 20 of the Constitution, which defines Associate Grade of Membership, in more positive terms. The Directors further agreed to refer the proposed amended language of C 20 of the Constitution to the Constitution Committee for proper handling.

As pointed out by the Chairman of the Membership Grading Committee, the current language of C 20 infers that men who cannot meet the requirements of Member Grade and who are elected to Associate Grade have been given second-rate citizenship in SAE.

The proposed amendment to C 20, as accepted by the Directors, defines Associate Grade in more positive terms and eliminates the negative interpretation created by the current language.

6

B 28 of By-Laws Amended

The Directors approved amendment of B 28 of the By-Laws to increase the appointed number of members on the Finance Committee from four to six. The By-Law, as now worded, reads as follows: "The Finance Committee shall consist of the Treasurer and ~~four~~ six other members. One of the appointed members shall be appointed Chairman."

The action taken by the Directors at this meeting satisfied the requirements for amending the By-Laws as prescribed in C 9 of the Constitution. The amendment becomes effective immediately.

7

American Standards Association Ballot

The Directors confirmed President Chesebrough's affirmative vote on the ASA ballot listing the noncompetitive slate of members of the ASA Board of Directors to serve for three years, beginning Jauary 1, 1961:

Nominated by the Manufacturers Standardization Society of the Valve and Fittings Industry
Mr. Carl H. Simon, Executive Vice-President, Darling Valve & Manufacturing Company

National Association of Purchasing Agents
Mr. Kenneth A. Cruise, Material Manager, Kansas City Division, Bendix Aviation Corporation

Nominated by the National Board of Fire Underwriters
Mr. L. A. Vincent, General Manager, National Board of Fire Underwriters

National Safety Council
Major-General George C. Stewart, USA (Ret) Executive Vice-President, National Safety Council

The Telephone Group
Mr. Walter G. Wright, Vice-President-Operations (Re-election) General Telephone and Electronics Corporation

Nominated by the Board of Directors (Member-at-Large)
Mr. Arthur S. Johnson, Vice-President and Manager, American Mutual Liability Insurance Company

It was reported that several years ago the Council had delegated authority to the President to sign ASA ballots of such routine nature, subject to later confirmation.

8

Other Board of Directors' Actions

The Directors approved the Membership Grading Committee's recommendation that the San Francisco State College of San Francisco, California, be added to the list of schools from which SAE may accept Enrolled Students.

The Directors acted favorably on 133 applications for membership, approved the transfer of Grade of 6 members, denied membership to 24 applicants and did not approve of 2 requests for transfer in Membership Grade.

The Directors approved a list of 334 Technical Committee reports approved and issued by the Technical Board during the 12-month period from December 1, 1959, to December 1, 1960.

The Directors approved President Kucher's appointment of personnel to Administrative Committees and the three Operating Boards. They also confirmed President Kucher's appointment of the following to the Executive Committee of the Board of Directors:

A. A. Kucher, Chairman

H. E. Chesebrough	H. L. Hibbard
G. A. Delaney	E. J. Manganiello
M. L. Frey	Leonard Raymond

9

Director Selected To Fill Board Vacancy

Frank W. Fink, Vice-President of Ryan Aeronautical Company, was selected by the Directors to fill the vacancy on the Board created by Dr. Kucher's election to the Presidency.

Immediately following the meeting, Mr. Fink was contacted and he was pleased to accept the directorship.

President Kucher had one year remaining (the year 1961) of his two-year term as a Director on the Board when he was elected to serve as 1961 President. Mr. Fink will complete the unexpired term. (See Page 93 of March, 1961, SAE Journal.)

10

Security Clearance

As required by the Eastern Industrial Security Regional Office of the Air Research and Development Command, the Directors approved the resolution with regard to handling of classified material at SAE Headquarters. This resolution, which is handled as a routine matter each year, specifies that the members of the SAE Board of Directors have no need to have access to classified military material in possession of security-cleared SAE staff personnel. The resolution further specifies the staff members who have authority for processing and handling classified information.

POWERPLANT Activity Expands to New Fields

C. E. HABERMANN, 1961 chairman of EAB's Powerplant Activity Committee.

R. A. PEJEAU heads new Marine Propulsion Subcommittee of EAB's Powerplant Activity Committee.

FIVE SUBCOMMITTEES have been found necessary to cover the greatly expanded scope and opportunities of the Powerplant Activity Committee, F. A. Robbins, the Committee's Engineering Activity Board sponsor reports.

The Powerplant Activity Committee now covers five major areas, at least two of which have become active since EAB became a stimulant to growth in this SAE area. Covered now are:

- Gas turbines for surface vehicles.
- Diesels for surface vehicles.
- Small engines, such as those used for lawnmowers, outboards, etc.
- New types of powerplants, including advanced methods of energy conversion.
- Large marine powerplants and drive systems used for inland, harbor, and coastwise vessels.

The expanded, 5-subcommittee organization was developed last year at seven meetings of Powerplant Activity's Executive Committee. Participating actively in the development were 1960 Committee Chairman Gregory Flynn, Jr., and 1961 Committee Chairman C. E. Habermann.

Newest of the fields to get attention is that of large marine powerplants. This subcommittee is headed by R. A. Pejeau of GMC's Cleveland Diesel Engine Division.

Pejeau already has announced that a full day at the 1961 SAE Summer Meeting will be devoted to marine diesel applications and ship control. Papers already scheduled for that meeting will discuss the U.S. Navy's postwar diesel installations; marine engines used in Mississippi River Boats; how to govern these big marine engines; and bow-thrusters and their application to maneuver river boats.

The other four Powerplant Activity Subcommittees and their chairman for 1961 are: Diesel — L. D. Evans, International Harvester Co.; Gas Turbine — W. A. Turunen, General Motors Corp.; Small Industrial and Marine — J. H. Budd, Textron, Inc.; Advanced Energy Conversion — P. S. Myers, University of Wisconsin.

All told, the Powerplant Activity Committee is planning eight sessions at the 1961 SAE Summer Meeting at the Chase Park Plaza Hotel, St. Louis, June 5–9.

SAE NATIONAL MEETINGS

1961

- **April 4–7**
  National Aeronautic Meeting (including production forum and engineering display), Hotel Commodore, New York, N. Y.
- **June 5–9**
  Summer Meeting, Chase-Park Plaza, St. Louis, Mo.
- **August 14–17**
  National West Coast Meeting, Sheraton Hotel, Portland, Ore.
- **September 11–14**
  Combined National Farm, Construction and Industrial Machinery; Powerplant; and Transportation Meetings (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.
- **October 9–13**
  National Aerospace Engineering & Manufacturing Meeting (including engineering display), The Ambassador, Los Angeles, Calif.
- **November 9–10**
  National Fuels & Lubricants Meeting, Shamrock Hotel, Houston, Texas

1962

- **January 8–12**
  Annual Meeting (including engineering display), Cobo Hall, Detroit, Mich.
- **March 12–16**
  National Automobile Week (combined National Automobile and Production Meetings), The Sheraton Cadillac, Detroit, Mich.

Too Many Society Meetings For Aerospace Engineers?

SAE Director **Frank W. Fink** reports on "multiplicity of technical meetings."

"MOST OF THE NOISE about multiplicity of technical meetings seems to come from the area of aircraft, missile, space, and electronic companies," Frank W. Fink said recently in a report to the SAE Engineering Activity Board.

Fink, now an SAE Director, cited a previous report by W. C. Heath (SAE Journal, October, 1959, p. 95) . . . and indicated his own feeling that SAE cannot logically be criticized for holding too many meetings in the aerospace field. He reported as follows:

The basic problem boils down to one of too many technical societies representing the many different engineers within the aircraft, missile, space, and electronic companies. Any of these companies that employ a few hundred engineers will find that they have engineers belonging to one or more of a dozen different technical societies such as SAE, ASME, IAS, ARS, AAS, IRE, AIEE, AES, SAFE, etc.

However, it should be noted that very few individual engineers belong to more than one or two technical societies and seldom take an interest in more than one. As a result, it may be noted that, although two or three societies may duplicate much of the same material at each of their national meetings coming in nearly the same time period, there will be very few engineers who even desire to attend more than one of these meetings. I made a check of our engineers at the Ryan Co. and found that only four engineers attended a national meeting of two different technical societies during all of the year 1960.

There was a notable exception to the above statement in that I did not include those duplications where an engineer attended the IAS national meeting held in San Diego in 1960. Since this meeting was held close to the plant, no travel expense was involved and very little time from work was lost, we did have a sizable number of engineers who attended one or more sessions of that meeting. This, I would like to point out is a good reason for having either regional meetings or national meetings held in various parts of the U.S.

Most national meetings draw a majority of their attendance from within a few hundred miles of the meeting place. Therefore, when SAE has one national aerospace meeting in New York City and its only other national aerospace meeting in Los Angeles, it means that more different engineers are able to attend a national meeting. At the same time it means that any one company can send a given number of engineers to the national meeting closest to their plant at much less expense.

W. C. Heath wrote an excellent article on this subject of multiplicity of meetings which was presented to the SAE Council on June 19, 1959. He pointed out that (1) the SAE has a responsibility to its members to hold meetings where they can get together to give and discuss papers; (2) that the members themselves put together the subject matter presented at such meetings; (3) that it is up to the companies to decide and control the number of engineers that they want to attend; and (4) that it is up to the technical societies and their members to educate the management of companies as to the value of the technical society to the company and its engineers.

Any given technical society must do an intelligent job of handling the number and type of national meetings it schedules. One society in a relatively narrow field of interest is boasting of ten national meetings in 1961. SAE, on the other hand, in this same field of interest schedules only two national meetings—one on the East Coast and one on the West Coast. Thus, how can SAE logically be criticized for holding too many meetings in this subject area?

I think our job in SAE is to sell the **fact** that we are giving the type of program for which its members, and the companies for which they work, can be assured is of maximum benefit to the advancement of the aerospace engineering fraternity within the bounds of the charter of a technical society.

1960 Manly Medal Goes to Mackay

MANLY MEMORIAL MEDALIST for 1960 is Donald B. Mackay of North American Aviation's Missile Division . . . for his paper on "Secondary Power Systems for Space Vehicles."

SAE's National Aeronautic Meeting Banquet, Thursday evening, April 6, at Hotel Commodore, New York, is occasion of the presentation.

The winning paper was originally given at SAE's 1960 Los Angeles Aeronautic Meeting. The complete paper will be published in 1961 SAE Transactions.

Donald B. Mackay

Dr. Mackay received his B.S. degree in mechanical engineering from University of Utah in 1939, and his Ph.D. from University of Michigan in 1954. He has held teaching positions at the Universities of Iowa, Kansas, and Utah. His chief industrial work has been design of gas turbines at Elliott Co.; research in heat transfer at Douglas Aircraft; and analyzing systems for secondary power, temperature control, fuel hydraulic systems for North American Aviation, Inc. For the past three years, Mackay's energies have been directed toward space travel. Analytical results of a number of his studies of problems associated with generation of power and maintenance of temperature control are about to be published in textbook form.

Selection of the winning paper was made by the Manly Medal Board of Award, consisting of Robert Johnson, chairman, S. K. Hoffman, and D. D. Streid.

New Local Goals in Placement Work

THE SAE PLACEMENT COMMITTEE plans new help to local Placement chairmen. Its aim: to use to a maximum the local potentials for aiding SAE members to better job opportunities. These local potentials are often far greater than those practiced for development on a national basis, Placement Chairman Thomas M. Dunn reports.

Thomas M. Dunn, SAE Placement chairman.

Specific moves to stimulate local effort were developed at a recent Placement Committee meeting. They include:

- Mentioning the Placement Service in Section meeting notices . . . and on the bulletin boards at Section meetings.

- Suggesting that Sections choose the Placement chairman from among those with an aptitude for this work . . . and keep him aware of the importance of his contribution to the individual, the industry, the Section, and nationally.

- Keeping a weather eye out for new companies to be added to the list of companies receiving Placement Bulletins.

- SAE Headquarters to participate by sending Faculty Advisors, Placement Chairmen, and Student Chairmen in the Sections a list of companies making regular use of Placement Service.

CHICAGO DAILY NEWS on Jan. 7, devoted a full page to "Autos, F.O.B. Chicago," under the byline of Murray Fahnestock (M'21), Pittsburgh Section's archivist.

"More than 120 cars and trucks once rolled off production lines in the Chicago area," Fahnestock stated . . . and proceeded to describe a number of them. All but two were produced during the first ten years of the century.

It all started when Archivist Fahnestock dug up a list of 40 cars and trucks which had originated in Pittsburgh Section's Western Pennsylvania territory . . . and Pittsburgh Press gave three pages to it in its Sunday magazine. SAE Journal carried an item on this one in its January, 1960 issue — p. 119.

Secor D. Browne (center) discusses program possibilities for future Aerospace sessions with Edward C. Wells (left), Boeing vice-president of engineering, and Wellwood E. Beall, Boeing senior vice-president (right). Browne is a member of the Joint Subcommittee of the aerospace Activity Committees for the 1962 SAE Annual Meeting.

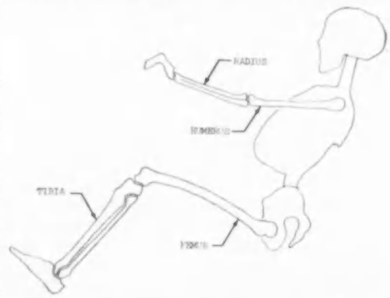
SAE LETTERS FROM READERS

From:

S. P. Geoffrey (J'59)
Product Design Engineer
Body Trim and Seating Department
Ford Motor Co.
Dearborn, Mich.

Dear Editor:

In the Chips section (p. 25) of the February issue of SAE Journal, you misrepresent the SAE Oscar Study, A 2-D MANNIKIN — THE INSIDE STORY, which was conducted by your own Body Activity Committee. You have falsely conveyed the idea that the pictured illustration (used in the SAE



paper merely to identify the four major human long link bones) is a tool used by Ford engineers in designing seats. Actually "this faceless fellow who sits so comfortably on nothing" would best be called the SAE OSCAR since Ford, General Motors, and Chrysler participated in over a year of research under the auspices of the SAE Body Activity Committee. The work was done to obtain the most complete and reliable accumulation of car posture data in the automobile industry.

In the event any further reference might be made to this work and in order to insure the SAE of due credit for accomplishment in a relatively unknown field, I strongly suggest the writer *read* the paper before writing his article.

GETTING TOP QUALITY SAE PAPERS is aim of new "guideposts" authored by the Engineering Activity Board's Publications Advisory Committee. Its title: "How to Get the Best SAE Papers. (A more detailed description of the 11-pp. booklet appears on opposite page.)

New Guideposts Aimed at Getting Best SAE Papers

THE ENGINEERING ACTIVITY BOARD'S Publications Advisory Committee has authored a new set of "guideposts" aimed at developing top-quality meeting papers. The 11 page booklet titled "How to Get the Best SAE Papers" suggests:

- Specific steps toward insuring paper subject matter which brings into SAE technical information needed and desired by SAE members.

- Ways to find and tap sources for such information.

- Appointment of a "session organizer" for each meeting — who is familiar with the topic and whose duty it is to invite the papers and work with the authors."

- Techniques for inviting authors.

- Specific criteria and procedures for appraising papers . . . immediately after their receipt by the "session organizer."

Chairman Raviolo of EAB's Publications Advisory Committee arranged for personal distribution of the guideposts to all members of EAB Engineering Activity Committees.

Additional copies are available on request to W. I. Marble, Manager, Engineering Activity Division, at SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

1961 Annual Meeting Draws N. Y. Students to Detroit

STATE UNIVERSITY, N. Y. mechanical power seniors during a tour of GM Technical Center while participating in SAE's International Automotive Engineering Congress in Detroit.

PROF. W. H. MOORE (M'40) and 23 of his senior mechanical power students from State University's Agricultural and Technical Institute in Farmingdale, N. Y., made the 600 mile trip to Detroit in a chartered bus to attend SAE's International Congress of Automotive Engineering in Cobo Hall in January.

Session Attendance Planned

Under Professor Moore's aegis, plans for the trip were started early in December . . . and before leaving New York, each student had been assigned a particular phase of the Congress to cover in a paper for presentation to the faculty and fellow students on return to the Institute. Monday afternoon of the Congress, all day Tuesday and Wednesday, and the morning and evening of Thursday were spent in technical sessions. The remaining time was given to touring the Science Pavilion, the Engineering Display, and to guided plant trips in the Detroit area.

Considered by the group as one of the high points of the trip, Professor Moore said, was the time spent during the Dearborn tour with Esso's Andrew Barr . . . and particularly on the return trip to Detroit when he, and three of SAE's foreign visitors, Gaston de Castelet, Mineo Yamomoto, and Hiromichi Nakamura, were the students' guests in their chartered bus back to Detroit.

The cost of the entire trip for each student was under $75 — or about $12 a day. This included transportation, room and board at the YMCA for six days, and all extras.

AN OPTION . . . "Any member residing outside Section territory, upon written request for assignment to membership in a given Section may be so assigned.

"Such a member can select only one Section."

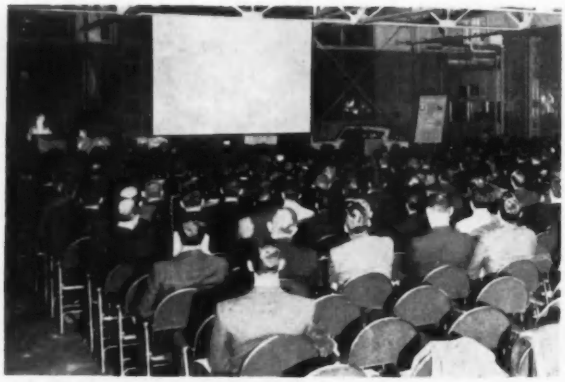
The above information (pertinent to about 5% of SAE members who live outside Section or Group territory) is printed at the request of SAE Board of Directors.

Request for assignment to a specific Section or Group should be addressed to Sections Department at SAE Headquarters.

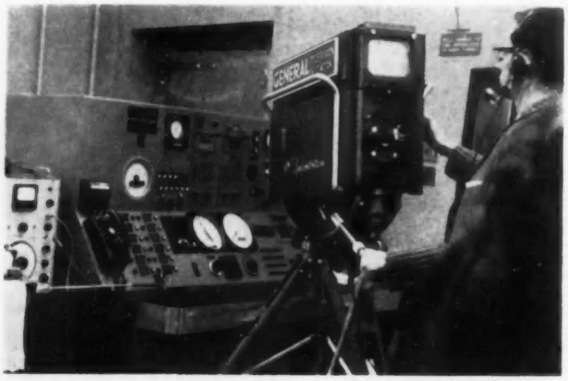
FORD Is Host . . .

. . . to Detroit Section Junior Activity

More than 300 see unique wind-tunnel tests via television; inspect Ford's



A partial view of the audience and the large screen used to show audience (via closed-current television) actual tests being made in Ford wind tunnel.



A television camera "zeroes in" on one of the control consoles used to regulate the Ford wind tunnel ("Hurricane Road").

Charles A. Freeman, Ford's supervisor of the Special Test Unit, Vehicle Testing Laboratories, gives SAE members an introduction to "Hurricane Road."

L. R. Ross, production product engineer at Ford's Continental-Thunderbird assembly plant, greets members and guests at dinner preceding the meeting. Ross was program chairman for this meeting.

Members view a tire-pressure-temperature survey car and display board set up in garage area outside the climate chamber. At right is SAE President Dr. A. A. Kucher; next to him, C. R. Briggs, public and professional relations manager of Ford's Engineering and Research Staff.

Meeting.

closed circuit

"Hurricane Road."

ABBREVIATED WIND TUNNEL TESTS of a Ford Anglia and a Mercury for fuel economy, noise suppression, and engine cooling were witnessed via closed-circuit television by more than 300 Detroit Section members and guests at Ford Motor Co.'s "Hurricane Road" on Feb. 20. Sponsor of the unique evening session was the Section's Junior Activity, led by its program Chairman Walter F. McCoskey of Ford's engineering staff. Chairman for this particular meeting was Ford's Louis R. Ross, Jr.

Ford provided bus transportation. The visiting engineers dined prior to the wind-tunnel test demonstrations in the Skyline Terrace Cafeteria at the Ford Body Engineering Building.

Following dinner, the engineers were taken by bus to the building where the Ford wind tunnel is housed. There they were seated in a garage area used for preparation of vehicles designated for tests in the wind tunnel. The area was turned into an auditorium for the evening.

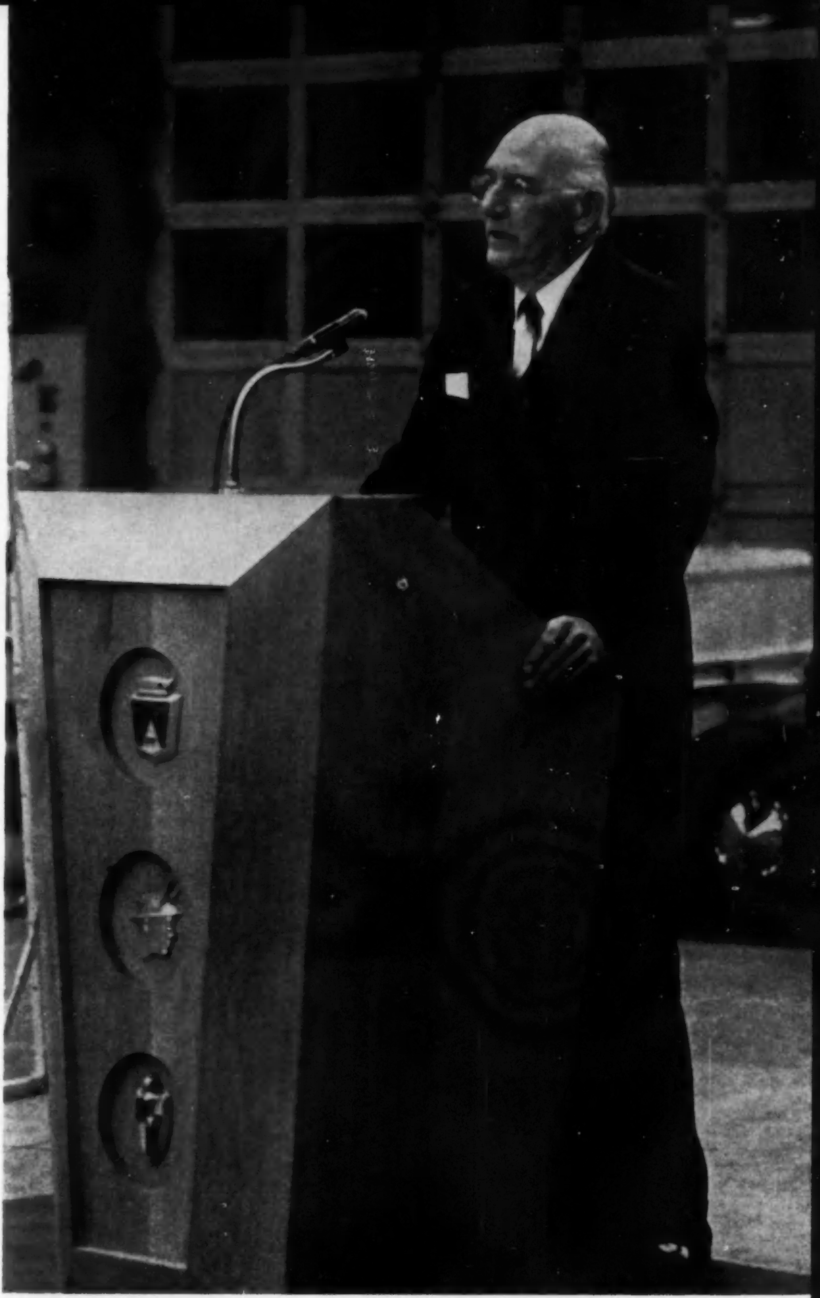
SAE President A. A. Kucher welcomed the group to Ford and then turned the meeting over to Ross.

Introducing the actual tests which were viewed on a screen via closed-circuit television (as shown in an accompanying illustration), Ford's Charles A. Freeman, Jr. noted that the Ford wind tunnel has proved to be an ideal tool for rapid radiator and engine cooling-system development work. Also, he said, the addition of wind-tunnel air-heating and cooling systems has extended the operating and temperature range from 120 F down to -20 F . . . and extended the scope of testing to include such components as heaters, defrosters, ventilating systems, fuel systems, and, of late, vehicle air conditioners.

The Anglia and Mercury cars which were used in the actual tests entered the wind tunnel through the area in which the audience was seated. As the tests went forward, they were described by Ford engineers located back in the wind tunnel area adjacent to the television cameras. Those giving these on-the-spot descriptions of the tests were Ford engineers William G. Cato, Jerome F. Meek, Thomas E. Dreaver, and Edward L. Richardson. (SAE Journal in May will carry a technical article based on written material prepared by these engineers detailing "Engineering Applications of Ford's Hurricane Road.")

Abbreviated tests were run for fuel economy, noise suppression, and engine cooling.

Following completion of the tests, the visiting engineers studied at close range the inside of the wind tunnel and its equipment. They also were given an opportunity to inspect the closed-circuit television equipment which had been provided by the GianTView General Television Network. The Network provided also the crews to operate the equipment and the large-screen on which the telecast was viewed.



SAE PRESIDENT A. A. Kucher, vice-president engineering and research of Ford Motor Co., welcomed an overflow audience to the meeting which saw Ford's "Hurricane Road" in action. . . .

Rambling through

VTOL AIRCRAFT . . . HYDROGEN FUEL POWER SYSTEMS IN ORBITAL VEHICLES . . . A FABRICATED, BRAZED, STAINLESS STEEL ENGINE . . . were subjects presented before three **NORTHERN CALIFORNIA SECTION** meetings in January.

At the Stockton Sacramento-Division meeting on Jan. 19, J. B. Nichols, Hiller Aircraft Corp.'s manager of advance planning, described and analyzed VTOL aircraft by displaying them as a continuous spectrum of technical and economic parameters.

Before the South Bay Division January meeting John G. Kimball, of AiResearch Manufacturing Co.'s Missile Systems Engineering, described the hydrogen fueled power systems and how they would be put into orbital vehicles. . . .

And on Jan. 25 a fabricated, brazed, stainless steel engine weighing 175 lb. but developing 175 hp. was discussed by T. C. Tyce, Tyce Engineering Corp. at the Section's meeting in San Francisco on Jan. 25.

SOUTHERN CALIFORNIA SECTION received 335 applications for its December McCulloch Corp. plant tour . . . but had to turn down 75 due to lack of accommodations. The 260 who participated were welcomed by Section Chairman J. F. Beach, and Section Vice Chairman for Production, John H. Shandorf. W. B. Burkett, McCulloch's assistant chief engineer, accompanied the group on the tour and gave a short talk on the history of the plant.

(Left) W. B. Burkett, McCulloch Corp.'s asst. chief engineer; (center) J. F. Beach, SOUTHERN CALIFORNIA SECTION chairman; and (right) John H. Shandorf, the Section's vice chairman for production . . . during the Section's tour of the McCulloch plant on Dec. 12.

Dr. Wernher von Braun (center) chats with DETROIT SECTION Chairman Max M. Roensch (left) and Section Aerospace Activity Vice-Chairman Charles W. Williams prior to his talk on "Lunar Exploration" at the Section's Feb. 6 meeting . . . 1200 members and guests turned out to hear him.

Three DETROIT SECTION recipients of 50-yr SAE membership plaques talk over past experiences, while Max M. Roensch, Detroit Section Chairman (standing) looks on. Seated (left to right) are Roscoe C. Hoffman; Ralph S. Lane; and SAE's 1920 President, Jesse G. Vincent. A fourth "50-yr member," E. V. Rippingille, was unable to make the trip from Florida tu attend the Section's December meeting where the ceremony took place.

A JET in the 600 mph range that will operate efficiently carrying 80–100 passengers over distances of about 1500 miles concerns Trans-Canada Airlines more than supersonic flight . . . said TCA's Clayton H. Glenn at **ONTARIO SECTION'S** Jan. 19 meeting.

the Sections

Seven OREGON SECTION Past-Chairmen were joined by an SAE Past President at a recent Section meeting. Front row (starting left) are E. A. Haas; Theodore Bokemeier; Milton Winters; SAE 1953 President Robert Cass; M. L. Gordon (current Section chairman); and C. A. Dillinger. Back row (left) E. E. Werlein; Floyd D. Chapman; and Clarence Bear.

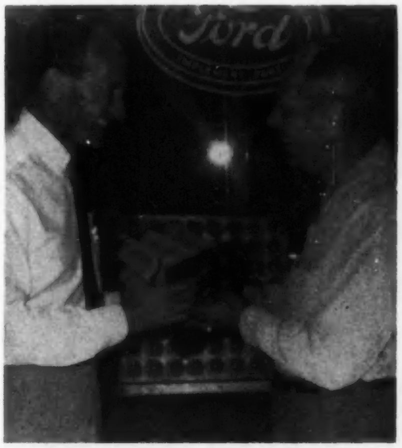
Among OREGON SECTION members and their ladies, celebrating Annual Ladies' Night are (left to right, seated): Section Vice-Chairman Fred Fulton; Mrs. Milton Winters; 1959–1960 Chairman Milton Winters; Mrs. Robert Cass; SAE 1953 President Robert Cass; and Mrs. M. L. Gordon. (Left to right — standing) E. A. Haas; Margaret J. Haas; Mrs. Fred Fulton; Current Section Chairman M. L. Gordon; Mrs. Robert Gaulke; and Section T&M Vice-Chairman, Robert Gaulke.

WASHINGTON SECTION Chairman I. W. Rhodes presents 35-yr SAE membership plaques to Philip B. Taylor (left picture) and Karl Ford Walker (right picture) at the Section's November meeting.

How two General Motors Divisions combined to produce "Project Corvair" was told **MID-MICHIGAN SECTION** members on Jan. 31. Bart Cotter, Fisher Body Division chief engineer, told of the extreme accuracy required in attaching the power train and suspension systems directly to the underbody . . . and Edward H. Kelley, Chevrolet's general manufacturing manager, detailed the production problems brought about by Corvair's novel design, its rear engine, and the high use of aluminum.

THE QUESTION AND ANSWER period following paper presentation on Pontiac's new Tempest engine by Assistant Chief Engineer John Z. DeLorean, was a feature of the Jan. 19 joint meeting of SAE's **ST. LOUIS SECTION** with the Engineers Club of St. Louis.

A CENTRIFUGAL PUMP — capable of handling up to 85% solids from the size of peas to larger than most oranges — was described by Howard Goss, E. R. Bacon Co.'s president before **HAWAII SECTION'S** Jan. 24 meeting. At the same meeting, Bacon Co.'s C. R. Read told about a dry-type, 2-stage filter which, he said, has an efficiency of 99.6%.



Speaker at HAWAII SECTION'S Jan. 24 meeting, Howard Goss, E. R. Bacon Co.'s president (left) discusses air filters with his company's automotive engineer, C. H. Ahlf.

Rambling through

B-70, THE NEW SUPER-BOMBER with a speed faster than that of an M-1 rifle, can reach trouble spots in a hurry and at altitudes above the effective range of most enemy defense weapons . . . Benjamin G. Peterson, North American's B-70 Airframe Subsystems project engineer told a **CLEVELAND SECTION** audience on Jan. 16.

Looking into the future, he indicated, the B-70 concept could have considerable influence on space flight . . . and on development of a fast new type of transport plane.

WESTERN MICHIGAN SECTION had widely varied topics at its first three meetings of the 1960–1961 Section year . . . Continental's 750-hp diesel . . . Allison's GMT-305 "Whirlfire" gas turbine . . . and ignition systems for internal combustion engines.

I. E. Parsons, Continental's Ordnance Division engineering manager, said Continental had decided on air-cooling for its diesel because air-cooling decreased the engine's weight by 15%. A 51½-ton tank using this engine, he said, can be air-dropped. . . . Allison's John N. Wetzler said the multifuel "Whirlfire" can operate on JP fuel, Nos. 1 or 2 diesel fuels, or on unleaded gasoline. . . . And L. P. Atwell, chief engineer of Electric Autolite's spark plug division, named five advantages for a low-voltage ignition system: Can use universal-heat-range spark plugs; eliminates preignition; eliminates spark-plug fouling; decreases fuel problems; and increases spark-plug service-life.

G. Waine Thomas (right) received recognition for 35-yr SAE membership and Conrad A. Teichert, Sr., for his 25-yr membership from WESTERN MICHIGAN SECTION Chairman W. A. MacLaurin (center) at a recent Section meeting.

It took place at METROPOLITAN SECTION's Feb. 2 meeting . . .

SAE Past President Leonard Raymond (left) presents to Harry H. Kerr a plaque in recognition of his 50-yr. membership in SAE.

. . . AND Metropolitan Section Chairman Carl Ryan (left) presents Leonard Raymond with a plaque recognizing his 25-yr. SAE membership.

DEVELOPMENT OF A MODERN AIR CARGO FLEET geared to today's need for fast, low cost transportation is a pressing problem for the cooperative effort of military leaders and civilian airlines . . . according to Oklahoma's U.S. Senator A. S. Monroney when addressing **METROPOLITAN SECTION** on Jan. 5.

The Section on Jan. 26 heard John S. Wintringham, Ethyl's research advisor, talk on potential passenger car powerplants.. . . . And "snow or no" 67 Section members and guests turned out to hear Ford's Manager of Special Products, Thomas H. Rusk talk on central hydraulic systems and their fluid requirements at a luncheon meeting on Jan. 19.

Gathered at METROPOLITAN Section's Jan. 26 meeting to hear a paper on potential passenger car powerplants (starting left) are SAE Past President Leonard Raymond; Ethyl Corp.'s John S. Wintringham, speaker; Robert W. Hogan, Section past-chairman; Willard H. Keeber, Section Fuels and Lubricants asst. vice chairman; and Carl S. Ryan, Section chairman.

the Sections . . . continued

CHICAGO SECTION'S SOUTH BEND DIVISION Meeting on Jan. 23 was occasion for long-term SAE membership plaque presentations to three "Bendixites." T. H. Thomas (right) Bendix Products Division assistant general manager-automotive, officiated.

Frank C. Mock (M'11) (second from right) accepts his 50-yr plaque; Emil O. Wirth (M'36) (center) displays his 25-yr plaque; and Doug Hurley (left) displays the 35-yr plaque accepted in absentia for Edward B. Sturges (M'24).

THE CONVENTIONAL GASOLINE ENGINE is best suited to passenger car requirements — for the next several years at least — was the "sumup" of Richard B. Snead's talk before **TEXAS GULF COAST SECTION** on Jan. 16. Sneed, Ethyl's technical representative, presented his conclusion after comparing the reciprocating gasoline engine with the diesel, gas turbine, free piston, Curtiss-Wright's NSU, and the fuel cell.

TEXAS GULF COAST SECTION Chairman, L. P. Graff fuel requirements with Ethyl (center) discusses engine Corp.'s Frank M. Jaber (left) and R. B. Snead; (right) the speaker at the Section's January meeting.

Using a large oscilloscope analyzer at **KANSAS CITY SECTION'S** January meeting, Champion Spark Plug's Ross Nielsen imposed many common ignition faults on an ignition system mock-up . . . thus visualizing for his audience a latest electronic trouble-shooting method.

EIGHT HIGH SCHOOL STUDENTS from nearby Mishawaka High School were introduced to 100 SAE members and guests recently at a **SOUTH BEND DIVISION (CHICAGO SECTION)** meeting. Introductions were made by their MHS principal, R. R. Myers. The youngsters learned from AVCO's Kenneth Austin and Louis Votre that turbine-propelled hydrofoil or ground-effect vehicles promise to have a strong effect on military amphibious operations in the nuclear age. . . . Wheelabrator's chief research engineer, John C. Straub, chairmanned the session.

NUMERICAL CONTROL as a new manufacturing philosophy in industrial processes was covered by William D. Geist of Boeing's Applied Computing Services at **WICHITA SECTION'S** Jan. 19 meeting.

MONTREAL SECTION has registered a membership increase of more than 200% in the first ten years of its existence . . . it was brought out at the Section's 10th anniversary celebration last Fall.

Five meetings were held during 1949–1950 — its one year as a Group. Membership in that pre-Section year went up from 39 to 57. SAE Council in June, 1950 approved Section status for Montreal.

W. S. Cowell (second from left) was MONTREAL SECTION chairman in 1950–1951 — its first year as a Section. On occasion of receiving his certificate of 25-yr membership in SAE, he talks with 1960 SAE President Harry E. Chesebrough (left). Also in the group are K. H. Larsson, another 25-yr SAE member (second from right), and 1960–1961 Section Chairman B. H. Miller.

SAE's CEP News

COOPERATIVE ENGINEERING PROGRAM

AMS's Near One Thousand Mark

THIRTY-TWO new documents have been added to 958 SAE Aeronautical Material Specifications. Coupled with their issuance on January 15 is the release of 14 revised specifications.

A complete set of the new and revised AMSs is available in loose-leaf form to supplement those previously issued. Each set, along with a revised AMS Index, may be obtained from SAE Headquarters for $9.

AMS 2249 — Chemical Check Analysis Limits, Titanium and Titanium Alloys

AMS 2413 — Silver and Rhodium Plating

AMS 2491 — Surface Treatment of Polytetrafluoroethylene, Bonding Preparation

AMS 2515 — Polytetrafluoroethylene Resin Coating, 700–750 F Fusion

AMS 3344 — Silicone Rubber, 1800 psi (45–55)

AMS 3363 — Silicone Rubber Compound, Room Temperature Vulcanizing, 50,000 Centipoises Viscosity (Durometer 30–45)

AMS 3365 — Silicone Rubber Compound, Room Temperature Vulcanizing, 35,000 Centipoises Viscosity (Durometer 40–55)

AMS 3366 — Silicone Rubber Compound, Room Temperature Vulcanizing, 55,000 Centipoises Viscosity (Durometer 55–70)

AMS 3654 — Tubing, Electrical Insulation, Light Wall, Extruded Polytetrafluoroethylene

AMS 3655 — Tubing, Electrical Insulation, Thin Wall, Extruded Polytetrafluoroethylene

AMS 3870 — Ceramic Moldings and Extrusions, Dense Ultra-High Alumina (99% Al_2O_3)

AMS 4036 — Aluminum Alloy Sheet and Plate, Alclad One Side, 4.5Cu-1.5Mg-0.6Mn (Alclad one side 2024; -T3 Sheet, -T4 Plate)

AMS 4046 — Aluminum Alloy Sheet and Plate, Alclad One Side, 5.6Zn-2.5Mg-1.6Cu-0.25Cr (Alclad one side 7075-T6)

AMS 4215 — Aluminum Alloy Castings, Premium Grade, 5Si-1.2Cu-0.5Mg (C355)

AMS 4218 — Aluminum Alloy Castings, Premium Grade, 7Si-0.3Mg (A356)

AMS 4387 — Magnesium Alloy Extrusions, 2.3Zn-0.6Zr (ZK21A-F)

AMS 4438 — Magnesium Alloy Castings, Sand, 5.7Zn-1.8Th (ZH62A-T5), Precipitation Heat Treated

AMS 4912 — Titanium Alloy Sheet, 4Al-3Mo-1V, Solution Heat Treated

AMS 4913 — Titanium Alloy Sheet, 4Al-3Mo-1V, Solution and Precipitation Treated

AMS 5359 — Steel Castings, Sand, Corrosion and Heat Resistant, 15Cr-4Ni-2.3Mo-0.1N

AMS 5368 — Steel Castings, Investment, Corrosion Resistant, 15Cr-4Ni-2.3Mo-0.1N, Solution Treated

AMS 5545 — Alloy Sheet and Strip, Corrosion and Heat Resistant, Nickel Base, 19Cr-11Co-10Mo-3Ti-1.5Al, Vacuum Melted — Solution Heat Treated

AMS 5753 — Alloy, Corrosion and Heat Resistant, Nickel Base, 18Cr-17Co-4Mo-3Ti-3Al, Vacuum Melted — Solution Heat Treated

AMS 5812 — Steel Wire, Welding, Corrosion and Moderate Heat Resistant, 15Cr-7.1Ni-2.4Mo-1Al, Vacuum Melted

AMS 5813 — Steel Wire, Welding, Corrosion and Moderate Heat Resistant, 15Cr-7.1Ni-2.4Mo-1Al

AMS 5817 — Steel Wire, Welding, Corrosion and Moderate Heat Resistant, 13Cr-2Ni-3W

AMS 6430— Steel, 0.8Cr-1.8Ni-0.35Mo-0.2V (0.33–0.38C), Special Grade

AMS 6433 — Steel Sheet and Strip, 0.8Cr-1.8Ni-0.35Mo-0.2V (0.33–0.38C), Special Grade

AMS 7250 — Nuts, Self-Locking, Corrosion and Heat Resistant, High Strength, Prevailing Torque, All-Metal, 1200 F

AMS 7717 — Magnetic Alloy Sheet and Strip, Nickel-Iron Alloy, Forming Quality

AMS 7718 — Magnetic Alloy, Nickel-Iron Alloy

AMS 7719 — Magnetic Alloy Sheet and Strip, Nickel-Iron Alloy, Stamping Quality

AMS 2645D — Fluoroscent Penetrant Inspection

AMS 3240D — Synthetic Rubber, Weather Resistant, Chloroprene Type (35–45)

AMS 3653B — Tubing, Electrical Insulation, Standard Wall, Extruded Polytetrafluoroethylene

AMS 4057A — Aluminum Alloy Sheet, 4.5Mg-0.65Mn-0.15Cr (5083-H32)

AMS 4058A — Aluminum Alloy Sheet, 4.5Mg-0.65Mn-0.15Cr (5083-H34)

AMS 4117A — Aluminum Alloy Bars, Rolled, 1Mg-0.6Si-0.3Cu-0.25Cr (6061-T6)

AMS 5112E — Steel, Music Spring Wire, Best Quality

AMS 5525B — Steel Sheet and Strip, Corrosion and Heat Resistant, 15Cr-26Ni-1.3Mo-2.1Ti-0.3V

AMS 5573C — Steel Tubing, Seamless, Corrosion and Heat Resistant, 17Cr-12.5Ni-2.5Mo (SAE 30316)

AMS 5613D — Steel, Corrosion and Moderate Heat Resistant, 12.5Cr (SAE 51410)

AMS 5640F — Steel, Corrosion Resistant, 18Cr-9Ni (SAE 30303 and 30303Se), Free Machining

AMS 5743A — Steel, Corrosion and Moderate Heat Resistant, 15.5Cr-4.5Ni-2.9Mo-0.1N

AMS 7205B — Spring Pins, Tubular, Carbon Steel

AMS 7207B — Spring Pins, Tubular, Corrosion and Moderate Heat Resistant

Gurski, Hammond, and Trowbridge Head Standing Committees of Technical Board

1961 TECHNICAL BOARD members will be hearing reports and recommendations of three men who will head the Board's three standing committees. Joseph Gurski, D. B. Hammond, and R. P. Trowbridge will chair, respectively, the Technical Committee Guideposts Committee, Certificates of Appreciation Committee, and Publication Policy Committee.

Gurski

Joseph Gurski, a 1961 SAE director and manager of Ford's Chemical and Metallurgical Laboratory Services, was re-elected chairman of the Technical Committee Guideposts Committee. Last year this group completed the "SAE Technical Committee Guideposts," a booklet on policies and traditions emerging from successful technical committee operation. In it, practical aspects of committee operation and duties of chairmen are enumerated. Also given is an explanation of the Technical Board's relationship to Board Councils and technical committees. (The booklet is available to anyone who's interested . . . free of charge.)

Hammond

The Certificates of Appreciation Committee will continue to seek participants in SAE's Cooperative Engineering Program deserving of official recognition by the Technical Board. With **D. B. Hammond**, vice president, engineering, Willys Motors, as chairman, this group will solicit nominees from technical committee members, and review their contributions to SAE standards work.

Roy P. Trowbridge, director, Engineering Standards Section, General Motors, will head the Publication Policy Committee. This group recently developed and received Technical Board approval of:

Trowbridge

- A numbering system of all SAE ground vehicle reports (see p. 120). The system was devised to provide industry with more positive identification of SAE reports. It will be implemented in the 1962 SAE Handbook.
- A guide for converting fractions into decimals.
- Ground rules for gathering, under one cover, SAE standards of interest to a specific industry and for issuing them as a supplement to the SAE Handbook. These booklets would be known as TRs (Technical Reports).

LaQue Heads General Materials Council

LaQue

FRANCIS L. LAQUE's chairmanship of the General Materials Council was approved by the Technical Board in January. He succeeds Muir L. Frey, who has served as chairman since 1959 when the Council was created to expedite activities of technical committees dealing with iron and steel, nonferrous metals, nonmetallic materials, and fuels and lubricants.

LaQue, who is an International Nickel vice president and manager of its Development and Research Division, recently expressed his views on how these groups can further technical progress.

"During the past decade, the pace of technical progress has been determined by limitations of the properties of materials. Requirements of materials during the next decade will become more demanding, and materials will represent a large factor in our continuing progress.

"Advances in materials cannot be achieved simply, or maybe even largely, through the specific efforts of materials producers. Advances must be the result of cooperation between all branches of industry.

The SAE program provides a means whereby various segments of the automotive industry can join forces to contribute to material progress in their mutual best interests. Through the channels of SAE committee activities producers can secure the benefits of guidance from users by way of precise descriptions of what improvements are required.

"Similarly, users can receive at first hand timely information on the products of research as it is undertaken by producers. Help from fabricators, with respect to details of manufacturing, forming, joining, and treating operations enables the material supplier to become aware of processing problems and to insure that these will be dealt with effectively in materials improvement programs.

"In industrial technical development speed is often the key to success. SAE committees provide channels of communication that expedite progress by providing timely guidance during the process of materials development."

General Standards Council Chair Goes to Burks

Burks

MAJOR SHIFTS in work assignments of screw threads, parts, and fitting technical committees will be carried out under 1961 General Standards Council Chairman, George E. Burks, vice president, Research and Engineering, Caterpillar Tractor Co. These shifts, which were instituted last year under 1960 Council Chairman E. C. Brown, provide a more logical framework in which to meet industry needs.

Since 1959 when the Council was formed to speed handling of SAE standards work, five new committees have been formed. Three of these evolved from the now disbanded Parts and Fittings Committee when its responsibilities on non-threaded fasteners were assumed by the new Fasteners Committee.

The new groups and their respective chairmen are:

Involute Splines, Serrations, and Inspection Committee	L. N. DeVos
Fasteners Committee	James Boxall
Ball Stud and Tie Rod Socket Committee	H. M. Stahl
Speedometer and Tachometer Committee	To be appointed
Ball Joints Committee	To be appointed

First action of the new Involute Splines, Serrations, and Inspection Committee was to try to reconcile an SAE Aeronautical Standard (AS 84B — Involute Splines, Full Fillet) and the SAE Involute Spline, Serration, and Inspection Standard which appears in the SAE Handbook (same as ASA B5.15). A step in this direction was taken by R. F. Zogbaum, chairman of SAE Committee G-6, Splines and Serrated Couplings, when he outlined existing differences at a recent ISSI Committee meeting. These differences are being studied by a special ISSI subcommittee headed by A. S. Beam.

ISSI Committee members are also working with the British to resolve differences between a proposed British Standard on Involute Splines and the SAE Standard. Another ISSI group has been set up to develop an international standard, acceptable to the U. S. and Britain, based on millimeter modules for submission to the ISO.

The Fasteners Committee was created to consolidate SAE activity on threaded and non-threaded fasteners under one group. It inherited subcommittees on hose clamps, rivets, washers, and pins from the old Parts and Fittings Committee. At present, it is consolidating industry opinion on the difference between "bolts" and "screws" in an attempt to simplify the hegagon product line which now extends to hexagon bolts, finished hexagon bolts, and hexagon cap screws.

The Ball Stud and Tie Rod Socket Committee is expanding its present report to include specifications on optional designs of ball studs. Currently, it is soliciting user reaction to see if standardization of larger sizes (of ball studs) for off-the-highway operation is warranted.

Speedometer accuracy and ball joints used in carburetor and transmission linkages will be looked into by the Speedometer and Tachometer Committee and the Ball Joints Committee, respectively, when these groups are activated this spring.

"SAE J485" Typifies New Standards Numbering

A NONSIGNIFICANT numbering system to be applied to all SAE ground vehicle standards reports has been approved by the Technical Board. The system was devised to facilitate industry referencing of SAE reports . . . and to encourage their use.

Assignment of numbers to reports and their incorporation in the 1962 SAE Handbook is being coordinated by the Handbook editorial staff.

Pertinent features of the numbering system are:

- The nonsignificant letter J, together with a nonsignificant number, will be assigned to each SAE Standard, Recommended Practice, or Information Report. (An example would be J485.)
- The letters SAE will precede the J485 to identify the Society as the source of the report. (Example: SAE J485.)
- A revision letter will follow the number to identify technical revisions that might affect interchangeability or performance. (Example: SAE J485b. The b would denote that the report has been revised two times.)
- The numbering system will start fresh with the 1962 Handbook.
- Any further identification of an item or section within a given report will be added after the revision letter. However, the selection and use of such identification (many of which already exist) will be entirely at the discretion of the cognizant committee.
- Those present reports which already have numbers (mainly nonmetallic materials) will arbitrarily retain their present numbers.
- Present numbers *within* reports will still be used where there is widespread understanding and recognition, such as the steel numbers. (Example: SAE 1010.)

The choice of nonsignificant numbers was made because it is least likely to run into complications when applied to the wide diversity of technical information developed by ground vehicle technical committees. Although *significant* numbers would have the advantage of conveying additional information, the Publication Policy Committee, which developed the system, felt that the point of such a system was to bring a report and engineer together. After this, the report itself can do all secondary explaining, such as whether it's a recommended practice or a standard, or if it's on ferrous materials or screw threads.

The numbering system adopted is consistent in concept with the present nonsignificant numbering system used in aerospace reports produced under the Technical Board.

The letter J is inserted before each number to avoid confusion with numbering systems within reports and numbering systems of other societies.

24 New SAE Aerospace Reports

NEARLY 35,000 SAE Aeronautical Standards pass into the hands of engineers in aerospace industries each year. This flow of performance and design information will be increased by the recent issue of 24 new documents. A complete set of new and revised documents (shown below) are available from SAE for $6.15. Single copies are $.25 each. Minimum order of $1.

Name of Document	Purpose	Originating Committee
Wording, Terminology and Phraseology for Standards (AIR 71)	Provides standard wording used in preparing minimum performance instrument standards.	Committee A-4, Aircraft Instruments
Hydraulic Fluid Characteristics (AIR 81)	Evaluates hydraulic fluid characteristics from two standpoints: (1) Fluid formulation (2) The effect fluid characteristics have on hydraulic system design and on materials used in system components.	Committee A-6, Aerospace Hydraulic & Pneumatic Systems & Equipment
Powerplant Fire Detection Instruments — Thermal and Flame Contact Types (Turbine) (AS 430)	Specifies minimum requirements for powerplant fire detection instruments used primarily in turbine-powered civil transports. Covers three basic types of instrument used to protect powerplant installation, auxiliary powerplants, combustion heaters and other installations where fuel, oil or similar fires may occur.	Committee A-4, Aircraft Instruments
Ignition System Testing Metering and Power Supply Regulations (ARP 504)	Establishes design standard for power supply used developing aircraft engine ignition systems.	Aircraft Gas Turbine, Ram-Jet and Rocket Engine Ignition Subcommittee of Ignition Research Committee
Terminology Guide for Aircraft Gas Turbine Engines (AS 509)	Defines terms applied to aircraft gas turbine engines and their operation so they will be clearly understood and uniformly used.	Committee E-21, Design and General Standards for Aerospace Propulsion Systems
Method of Torque Determination for Tube or Hose End Fitting Connections, Flared Flareless, or Miscellaneous Screw Thread Style (ARP 600)	Gives three tests for determining torque values (minimum, ultimate failure, maximum) for tube or hose end connections.	Committee G-3, Aerospace Fittings & Flexible Hose Assemblies
Gasket — 18 MM Folded Steel Aircraft (AS 678)	Gives design criteria for spark plug gasket.	Piston Engine Subcommittee of Ignition Research Committee
Universal Turnover Build-Up Stand Series for Propulsion Units and/or Components (ARP 680)	Recommends practice for designing series of build-up stands which will be adaptable to small propulsion units and/or all propulsion unit components for specified classes.	Committee EG-1, Aerospace Propulsion System Support Equipment
Piloted Ring Seal Fluid Connection Bosses (AS 685)	Gives design criteria for 2-, 3-, 4-, and 6-bolt flanged bosses used with connection assemblies set forth in AS 687 (below).	Committee E-21, Design and General Standards for Propulsion Systems
Piloted Ring Seal Tube Connection Assembly (AS 687)	Provides index of parts and design standards related to piloted ring seal tube connection for use with bosses as set forth in AS 685 (above).	Committee E-21, Design and General Standards for Propulsion Systems
Cap Assembly — Pressure Seal, Flareless Tube Fitting (AS 1000)	Give design criteria for fluid fitting cap assembly.	Subcommittee G-3B, Fittings, of Committee G-3, Aerospace Fittings & Flexible Hose Assemblies
Union Assembly — Adjustable Flareless (AS 1017) Nut — Adjustable Flareless Union Assembly (AS 1018) Bulkhead Union Assembly — Adjustable Flareless (AS 1021) Bulkhead Union Assembly — Adjustable Flared (AS 1022) Nut — Adjustable Flared Bulkhead Union Assembly (AS 1023) Union Assembly — Adjustable Flared (AS 1024) Screw, Union Adjustable — Flared (AS 1025) Nut — Adjustable Flared Union Assembly (AS 1026)	Provides design criteria for use where tubing installation and/or its removal is otherwise impracticable. Parts are for use at operating temperatures from − 65 to 275 F.	Committee G-3, Aerospace Fittings & Flexible Hose Assemblies
Nut — Drilled Jam (AS 1927)	Gives design criteria for fluid fitting jam nuts capable of being lockwired.	Committee G-3, Aerospace Fittings & Flexible Hose Assemblies
Nut, Coupling, Flared Tube, with Lockwire Holes (AS 1028)	Gives design criteria for an AN818-type nut with lockwire holes.	Subcommittee G-3B, Fittings, of Committee G-3, Aerospace Fittings & Flexible Hose Assemblies
Nut, Sleeve Coupling, Flareless Tube, with Lockwire Holes (AS 1041)	Gives design criteria for an MS21921-type nut with lockwire holes.	Subcommittee G-3B, Fittings, of Committee G-3, Aerospace Fittings & Flexible Hose Assemblies

Revised Documents

AS	176A	TABLE OF LIMITS, LIMITS AND LUBRICATION CHARTS
AS	391C	AIRSPEED INDICATOR (PITOT STATIC) (RECIPROCATING ENGINE POWERED AIRCRAFT)
AS	395B	TURN AND SLIP INDICATOR (TURN AND BANK)
AS	468A	DRIVE-ACCESSORY, 5" BOLT CIRCLE
AS	469A	DRIVE-ACCESSORY, 8" BOLT CIRCLE
AS	470A	DRIVE-ACCESSORY, 10" BOLT CIRCLE
AS	471A	FLANGE-ACCESSORY, 5" BOLT CIRCLE
AS	472A	FLANGE-ACCESSORY, 8" BOLT CIRCLE
AS	473A	FLANGE-ACCESSORY, 10" BOLT CIRCLE
AS	481A	FLANGE PILOT-ACCESSORY, O RING SEAL
ARP	573A	SILVER AND COPPER ALLOY BRAZED JOINTS FOR AIRCRAFT POWERPLANTS

NOTE: An Index of SAE Aeronautical Standards, Recommended Practices, and Information Reports is available free of charge from SAE Headquarters, 485 Lexington Ave., N. Y. 17, N. Y.

SAE MEMBERS

DeLong

Fredhold

Heath

Haas

Christensen

WEBSTER D. CORLETT, chairman of the board of directors, and **JAMES A. TAYLOR**, president, have announced the realignment of executive responsibilities involved in the overall operation of Standard Screw Company.

Corlett continues as chief executive officer of the company but has ended his operating direction of The Chicago Screw Co. Division, Bellwood, Ill.

Taylor also continues as president, board member, and chief operating officer of Standard Screw.

JAMES E. DeLONG, president and chairman of the board of the Waukesha Motor Co., has retired from the presidency of the company. He will remain on the board of directors.

A graduate of Purdue University, he entered the internal combustion engine field with the Rutenber Motor Co. Later he became a director and secretary of the Rutenber Electric Co. During World War I, DeLong served as a first lieutenant with the combat engineers in the Army's first division. He was separated from the service in 1919 with the rank of captain. Returning to civilian life, DeLong became plant manager of Indiana Truck Corp. He joined the Waukesha Motor Co. in 1923 as oil field sales engineer. He advanced to plant manager in 1928 and director and vice-president in 1932. Four years later he became general manager and head of the company as its president.

He has been an active member of SAE for forty years.

ALLAN FREDHOLD has been elected to the presidency of Hadco Engineering Corp., a wholly-owned subsidiary of Interstate Engineering Corp. of Anaheim. He was formerly general manager of Hadco.

WILLIAM C. HEATH, long associated with Solar Aircraft, has joined Parts Engineering Co. of El Cajon, Calif., where he will head the company's sales. Parts Engineering specializes in aircraft and missile ducting and bellows assemblies. Heath is a Past SAE Director, has been active in many areas of SAE technical and administrative work, and currently is a member of both the Aerospacecraft and the Aerospace Powerplants Activity Committees.

WILLIAM C. HAAS has been appointed assistant project engineer, technical reports and proposals at Pratt & Whitney Aircraft's Florida Research and Development Center. Haas was formerly supervising engineer, technical publications at the Aviation Gas Turbine Division, Westinghouse Electric Corp.

WILLIAM CHISTENSEN has joined Performance Measurements Co. of Detroit to expand their Quality Control equipment and Inspection Test group. He formerly headed a group specializing in electromechanical testing equipment for the automotive industry under his own name, William Christensen Co.

DUNCAN McRAE and **BENJAMIN BOWDEN** are beginning to operate as consultants for their own company, Bowden, McRae Associates. McRae was formerly director of design for the Curtiss-Wright Corp. at South Bend and Bowden was formerly director of design for the John Wood Co. in Muskegon.

WILLIAM A. RAFTERY has been appointed a vice-president for Signal-Stat. Raftery formerly served Signal-Stat as general sales manager.


McRae


Bowden


Raftery


Gage


Allmendinger

JAMES L. GAGE has been named chief product engineer at Electric Autolite Co.'s new Decatur, Ala. operations. Formerly chief engineer, ignition and controls, at Autolite's central engineering headquarters in Toledo, Gage will have full engineering responsibility at the new plant which will produce distributors, regulators, and other light electrical items.

PAUL F. ALLMENDINGER has been appointed manager of engineering of the Alemite and Instrument Division, Stewart-Warner Corp. He was formerly chief engineer for automotive, marine, industrial and other instrument products. Allmendinger is a member of SAE Board of Directors and is chairman of SAE Sections Board.

P. E. TOBIN has been made vice-president-wholesale operations of the White Truck Division. Tobin returns to White after two years as owner of his own business in Bloomington, Indiana.

EDWARD N. CUNNINGHAM, formerly sales manager of Precision Rubber Products Corp., has been elected a vice-president of the company. Cunningham is currently chairman of SAE Committee G-4.

JAN UYTTERLINDE has been appointed export representative for Africa and the Middle East with Yale & Towne Mfg. Co. Uytterlinde formerly served Baker Industrial Trucks, Division Otis Elevator Co. as sales manager-gas trucks.

HAROLD C. STONE has been appointed chief metallurgist at American Steel Treating Co. Stone was formerly chief metallurgist for the Le Tourneau Westinghouse Co.

J. J. KROECKER has been appointed sales manager for The Permold Co. He was formerly plant manager for Mohawk Foundries.

ROBERT W. HALBERG has been appointed associate director-automotive department of the Roy C. Ingersoll Research Center of Borg-Warner Corp. Halberg was formerly on the engineering staff of Chrysler Corp.

CHARLES R. PLUM has been appointed director of marketing and custom services at Celanese Corp. of America. Plum formerly served as general manager of Defense Products Division, American Air Filter Co.

ROBERT A. BELL has been appointed vice-president in charge of sales and engineer at Mohawk Spring Co., Inc. Bell formerly served as chief engineer for American Spring & Wire Specialities.

RICHARD L. EUBANKS has been appointed president of The Randall Co., Division of Textron, Inc., and its subsidiary, The Wagner Mfg. Co. Eubanks was formerly executive vice-president of Randall.

CHARLES F. KETTERING was known all over America for his speeches on a huge variety of subjects. T. A. BOYD has distilled a collection most representative of Kettering himself in his book, "Prophet of Progress." This book is composed of selections from the speeches of Kettering.

Boyd spent years of research in the preparation of this collection of speeches.

Kettering was one time head of General Motors Research, and one of the most successful inventors of our century.

M. G. BEKKER has been appointed head of a newly formed Land Mobility Research Laboratory as part of General Motors Defense Systems Division. Bekker formerly served as technical director for U. S. Army Ordnance Tank Automotive Command.

MARSHALL E. MUNROE, JR., has been appointed director of procurement for Minneapolis-Moline Co. Munroe formerly served Massey-Ferguson, Ltd. as general purchasing manager, North American operations.

M. A. WILSON has been named manager of tire engineering for Goodyear Tire & Rubber Co., succeeding W. E. Shively who retired in December after 45 years with the company. Wilson had been assistant to Shively since last August.

Tobin


Cunningham

Uytterlinde


Stone

Kroecker


Halberg

Plum

SAE Members . . . continued from page 123

Obituaries

CHARLES F. BALL . . . (M'40) . . . retired engineering director, Joy Mfg. Co. . . . died January 10 . . . born 1892.

ERNEST W. BARTLE . . . (M'54) . . . tool planning supervisor, Orenda Engines, Ltd. . . . died August 29 . . . born 1900.

ARTHUR L. BRADLEY . . . (M'44) . . . president-treasurer, Aero Detroit, Inc. . . . died November 6 . . . born 1908.

TOM BRADLEY . . . (M'54) . . . chairman and president, Sheller Mfg. Corp. . . . died January 3 . . . born 1894.

T. ARTHUR CAMPBELL . . . (M'45) . . . development engineer, Stewart-Warner Corp. . . . died November 12 . . . born 1899.

W. HENRY CANTELON . . . (M'35) . . . president, Auto Specialties Mfg. Co. (Canada), Ltd. . . . died December 20 . . . born 1887.

WALTER A. CLOUSER . . . (M'46) . . . vice-president-sales, Muskegon Piston Ring Co. . . . died September 23 . . . born 1897.

CARL DANNEGGER . . . (M'37) . . . engineer, Ateliers de Bouchout et Thirion Reunis, S. A. . . . died August 30 . . . born 1887.

WALTER L. DIXON . . . (M'25) . . . vice-president, Dixon Marine . . . died December 31 . . . born 1890.

NORVIN V. FISCHER . . . (M'60) . . . commercial salesman, Standard Oil Co. (Ohio) . . . died June 28 . . . born 1906.

RAYMOND C. HAISS . . . (M'32) . . . retired . . . died December 15 . . . born 1891.

CARLYLE MAUNDER . . . (M'44) . . . product engineer, Bendix-Eclipse of Canada, Ltd. . . . died November 14 . . . born 1909.

RAYMOND C. NELSON . . . (M'56) . . . assistant chief engineer, Outboard Marine Corp. . . . died October 3 . . . born 1922.

MARIO P. VANO . . . (M'54) . . . staff member, Holley Carburetor Co. . . . died December 18 . . . born 1917.

A. M. YOCOM . . . (M'19) . . . automotive engineer, Raybestos Manhattan, Inc. . . . died September 8 . . . born 1892.

HORACE B. VAN DORN has been elected vice-president in charge of engineering at The Fafnir Bearing Co. Van Dorn formerly served at Fafnir as director of engineering.

WILLIAM W. MARES, formerly assistant marketing manager, Sperry Gyroscope Co., has become assistant marketing manager for Sperry Phoenix Co.

W. E. MEYER, professor of mechanical engineering at The Pennsylvania State University has co-authored with H. W. Kummer, a monograph "Rubber and Tire Friction", published as Engineering Research Bulletin by Pennsylvania State University.

GEORGE J. CLARK has been appointed engineer of equipment for the Chicago Transit Authority. He was formerly assistant to the superintendent, Technical Services Division, Chicago Transit Authority.

JOSEPH KIM has become extrusion plant manager for the Metals Processing Division, Curtiss-Wright Corp. Kim formerly served as general engineering manager for Curtiss-Wright.

C. H. WIEGMAN, formerly chief engineer of Lycoming Division, Avco Corp. has been appointed vice-president of engineering.

GEORGE T. MONAGHAN has become development engineer, propulsion systems for Allegany Ballistics Laboratory. He was formerly service engineer at General Electric Co.

ROWLAND G. OONK, formerly transportation coordinator — general manager for Suliman Olayan Contracting, has been appointed administrative manager at Penn-Mor Mfg. Corp.

CHARLES E. CHAMBLISS, JR., formerly zone fleet manager, Chevrolet Division, General Motors Corp., has become transportation engineer for Curry Transportation Division, Curry Auto Rental Co.

JAMES K. SEATTER, who formerly served as project engineer for Walker Mfg. Co., has been appointed quality control engineer at A. A. Smith.

BENJAMIN F. MOORE has been named assistant division manager for the Systems Engineering Division, Pneumodynamics Corp. Moore formerly served Pneumodynamics as director materiel.

WILLIAM D. RITTENHOUSE has been appointed structural engineer for North American Aviation, Inc. He was formerly mechanical engineer assistant for U. S. Army Transportation Research Command.

JOHN F. McLEAN, JR., formerly division sales training manager, Ford Division, Ford Motor Co., has been appointed truck marketing manager.

JAMES T. DICKINSON has been named wholesale parts and service manager for Cadillac Motor Car Division, General Motors Corp. Dickinson was formerly district parts and service manager for Cadillac.

JOHN E. THOMAS, formerly on loan assignment from Esso Export Corp., has been named manager for Enjay Chemical Co., Ltd.

BRIJ BHUSHAN RAI has been appointed plant manager for Delo Screw Products Co. He was formerly tool engineer for IBM.

ROBERT W. TRAVIS has been appointed capsule engineer for McDonnell Aircraft Corp. He was formerly designer for the company.

KENNETH R. SCHAPER, who formerly served as product technologist for Gulf Oil Corp., has become advisor product application — domestic marketing for Gulf.

DONALD DREWRY LOVE, formerly technical services division manager, Esso Export Corp., has become aviation advisor, eastern hemisphere for the company.

BENSON FORD, Ford Motor Co. vice-president, and chairman of the Dealer Policy Board, was named national chairman of United Community Campaigns of America for 1961.

ASA E. SNYDER has been named director of research at Pratt & Whitney Co., Inc. He formerly served as executive vice-president of U. S. Industries.

LEONARD F. GRIFFING has been named executive editor for Diesel Publications, Inc. He was formerly account supervisor at De Garmo, Inc.

DAVID W. WEISS has been appointed systems engineer for General Electric Co.'s defense systems department. He was formerly project engineer, Stratos Division, Fairchild Engine & Airplane Corp.

continued on p. 126

SAE Section Meetings

12th Annual

Earthmoving Industry Conference

SAE Central Illinois Section

April 4–5, 1961 **Pere Marquette Hotel, Peoria, Ill.**

TUESDAY MORNING — April 4

8:00 a.m. — Registration — Pere Marquette Hotel

9:30 a.m. — Madison Theatre
Welcome: **Jack A. Drais,** Chairman of Conference
Invocation: **Rev. Alfred D. Deutsch,** Marquette Heights Community Presbyterian Church

Keynote Address — "Earthmovers and Earth Shakers"
A. M. Sullivan, Editor, Dun's Review and Modern Industry

"Earthmoving in the Missile and Space Age"
Brig.-Gen. James B. Lampert, Director of Military Construction, Department of the Army

TUESDAY AFTERNOON — April 4

1:30 p.m. — Madison Theatre
"Design of Earthmover Tires"
James G. Berry, Acct. Mgr., United States Rubber Co.

"Service for Added Profit"
H. G. Rudolph, Jr., Automotive Division, Products Department, Socony Mobil Oil Co., Inc.

TUESDAY EVENING — April 4

5:30–6:30 p.m. — E.M.A. Cocktail Party (Admission by Ticket Only) Ballroom Pere Marquette Hotel

6:30 p.m. — E.I.C. — ANNUAL BANQUET — Pere Marquette
Banquet Speaker: **E. J. Tangerman** Editor, Product Engineering
"The Engineer — Threat to Society?"

WEDNESDAY MORNING — April 5

9:00 a.m. — Madison Theatre
"Earthmover Performance Evaluation Using a Digital Computer"
D. A. Lewis, Research Engineer, **W. C. Morgan,** Research Engineer, Research Department, Caterpillar Tractor Co.

"Earthmoving with NUCLEAR EXPLOSIVES"
Dr. Gerald Johnson, Associate Director, Lawrence Radiation Laboratory

WEDNESDAY AFTERNOON — April 5

1:30 p.m. — Madison Theatre

Panel Discussion

Production of a quality product, competitively priced, demands many decisions in the areas of design, manufacture, and procurement. A discussion of several important topics in these areas will be presented by the panel.
Moderator: **Merle Yontz,** President, LeTourneau-Westinghouse Co.
Winthrop W. Spencer, Mgr., Process Control Engineering Services, General Electric Co.
"Total Quality Control"
O. K. Gaskins, Mgr., Aircraft and Industrial OEM, Link Belt Co.
"The Suppliers Role"
D. W. Lysett, Vice-President, Long Division, Borg-Warner Corp.
"Designing for Economical Manufacture"
D. L. Heisler, Director of Purchases, Vickers, Inc., Div. of Sperry Rand Corp.
"The Make or Buy Decision"

DETROIT
April 18 . . . Junior Activity Meeting, Rackham Educational Memorial Bldg., Detroit. 8:00 p.m. Three simultaneous technical sessions: Noise and Vibration, Ignition Systems, Analysis of Body Stresses.

FORT WAYNE
May 10 . . . B. L. Douglass, Sunstrand Aviation. "Hydrostatic Transmissions for Vehicle Propulsion." Hobby Ranch House, Fort Wayne, Ind. Dinner 7:00 p.m. Meeting 8:30 p.m.

INDIANA
April 20 . . . J. S. Wintringham, Ethyl Corp. "Potential Passenger Car Power Plants." Purdue University, W. Lafayette, Ind. Dinner 6:30. Meeting 7.30.

METROPOLITAN
April 20 . . . Tour of Mack Trucks Plant, Plainfield, N. J. 2:00 p.m., with short lecture followed by guided tour of facilities. To end about 4:30.

MID-CONTINENT
April 21 . . . Dr. Burzoe Ghandhi, research engineer, Outboard Marine Corp. "2-Cycle Engine Fuels & Oil Requirements." Elks Club, Bartlesville, Okla. Dinner 7:00 p.m. Meeting 8:00 p.m.

MID-MICHIGAN
April 15 . . . Betty Skelton, account executive, Campbell-Ewald Co. "World's Most Unusual Advertising Job." Zehnders Hotel, Frankenmuth, Mich. Dinner 6:30 p.m. Meeting 8:00 p.m. Ladies' Night.

MONTREAL
April 17th . . . H. Whiteman, sr. project engineer, Canadair. "Anti Submarine Warfare and the Airplane." Sheraton Mt-Royal Hotel, Montreal. Dinner 7:00 p.m. Meeting 8:00 p.m.

OREGON
April 13 . . . Ed Eelerle, Ethyl Corp., "Stop and Go Driving." Washington Hotel, Portland. Meeting 8:00 p.m.

ST. LOUIS
April 11 . . . Panel on Fuels & Lubricants "Stump the Experts." Congress Hotel, at Pershing. Dinner 7:00 p.m. Meeting 8:00 p.m.

WASHINGTON
April 21 . . . Arthur B. Billet, staff engineer, Vickers, Inc. "GSE Components & Evaluation of Components used in 'Lady Be Good'". Officers Mess, Washington, D. C. Dinner 6:30, Meeting 8:00.

WICHITA
April 20 . . . Pierre Volkmar, gas turbines, AiResearch Mfg. Co. "Small Gas Turbines." Innes Tea Room, Wichita, Kan. Dinner 7:15, Meeting 8:00.

WILLIAMSPORT
April 3 . . . T. D. Cooney, electrical engineer, Piper Aircraft Corp. "Light Aircraft Radio Navigation Developments." Moose Auditorium, Williamsport, Pa. Dinner 6:45; Meeting 8:00.

SAE Members

continued from p. 124

EDMOND E. BISSON, National Aeronautics and Space Administration scientist, presented a series of lectures the week of January 23 in Paris. The lectures were presented in French to The French Institute of Petroleum, The Group for the Advancement of Industrial Mechanics, and the National Office for Study and Research in Aeronautics.

LOUIS E. LARSON has been appointed district service manager for Renault, Inc. Larson was formerly regional service instructor for the company.

DAVID W. LEE has been appointed manager, truck advertising department, Ford Division, Ford Motor Co. Lee formerly served Ford as truck field services manager.

ADOLF VARTANIAN, formerly associate engineer for Sperry Gyroscope Co., has become associate senior engineer for Hughes Aircraft Co.

STANLEY R. EVANS has been appointed salesman for Laher Spring & Electric Car Corp. Evans formerly served as technical service supervisor for Tidewater Oil Co.

JOHN L. KOETTING has been appointed supervising engineer at Westinghouse Electric Corp. Koetting was formerly section engineer for Westinghouse.

ARTHUR R. ROBBINS has become chief inspector for the Autocar Division, The White Motor Co. He was formerly director of Quality Control at Diamond T Motor Car Co.

WILLIAM A. TRACE, formerly project engineer, United Aircraft Research Laboratories, has been appointed sales engineer for Split Ballbearing Division of MPB, Inc. Trace formerly served as engineer, research department, United Aircraft Corp.

P. W. DREW has been appointed manager of the newly created tire engineering service department of Goodyear Tire & Rubber Co. He was formerly manager of auto tire design for Goodyear.

JAMES T. ALBERT formerly associate engineer for the Kellogg Division, American Brake Shoe Co., has been appointed junior development engineer, mechanical product development, aircraft fuel systems at Thompson-Ramo-Wooldridge, Inc.

Briefs of SAE PAPERS

continued from p. 6

suspension, chassis structure, and exterior styling; test program.

Proposed 463 L Materials Handling Support System, M. E. PETERSON, C. M. EDMONDS. Paper No. 283B. Background and approach applied in defining procedural and conceptual terms of complete cargo handling system; Douglas Aircraft Co. provided performance specifications for all equipment requirements; Air Force organizations involved and specific areas in which approved recommendations were made; systems recommendations and unit load concept, aircraft loading, cargo ground handling, terminals, freight preparation, and intransit control; each of areas is discussed.

Payload — Density — Mechanization As applied to All-Cargo Aircraft, J. A. MORLEY. Paper No. 283C. Analysis of Canadair Forty Four wing tail aircraft shows that use of preloaded containers and pallets, combined with mechanized cargo loading system, is essential for efficient cargo operation; flexible pallet, pulled into or out of main cargo compartment by chain and cable system, has design load capacity of 8000 lb and weighs 140 lb; essential part is cargo platform; other equipment required, fork lift trucks of 15,000- and 2000-lb capacity each, and standard ramp tug.

Prospects for Use of Mechanized Cargo-Handling Systems in Europe, R. MAURER. Paper No. 283D. Conditions of cargo operation in Europe where cargo handling is concentrated in centralized terminal and mostly carried on passenger aircraft; standardization of equipment and procedures must provide for as many aircraft types offering as many advantages as possible; loading of passenger aircraft and of freighters; four phases of loading procedures and vehicles and equipment developed for each stage; prospects for use of unitized loads.

U.S. Lunar Travel Program, D. H. HEATON. Paper No. S276. NASA lunar program has long-range objective of manned landings on lunar surface and establishment of lunar base for scientific observation; three phases of program, earth satellite, lunar, and planetary; unmanned lunar program and spacecraft types under development Able 5 and Ranger; Surveyor, designed for lunar soft-landing mission using Centaur launch vehicle, will deposit instruments capable of making direct measurements of chemical and physical properties of lunar crystal material.

Trends in Air Transportation, M. L. PENNELL. Paper No. S278. Analysis is expressed in terms of aircraft designs of future, subsonic and supersonic, domestic and international, passenger and cargo and shown graphically; problems involved in supersonic transport program such as take-off and landing speeds, design of control system and sonic boom; it appears that with vigorous growth over next 15 yr, production of supersonic transport may be economically attractive and could dominate field of long-range passenger transport by 1975.

Need and market for Short-range Jets. A. R. BERGESON. Paper No. S291. Brief discussion of business and economic factors involved in and predictions about possible business cooporation use of quantity-produced jet transports with 15,000 nautical mile range — when and if produced.

Automation in Air Traffic Control. ALBERT BROWN. Paper No. S293. Chief, Systems Engineering Div., Federal Aviation Agency discusses how FAA is meeting its responsibilities for modernizing and providing a common civil and military air traffic control system to meet present and future U.S. needs.

FUELS & LUBRICANTS

New Knock-Testing Methods Needed to Match Engine and Fuel Progress, E. BARTHOLOMEW. Paper No. 285-A. Summary of engine and refining advances which caused Research and Motor ratings to become less reliable indices of antiknock quality of gasolines in automobiles; improved "high-speed" test method must substantially duplicate Motor-method ratings of paraffinic fuels containing lead, and assign higher ratings to lead treated highly aromatic fuels than to lead-treated olefinic muels having same difference between Research and Motor ratings; future research.

Air-Fuel Ratio Control: Minimal Fix for Octane Ratings Over 100, D. FRAZIER, H. F. HOSTETLER. Paper No. 285B. Fuels containing large amounts of aromatics can give fallacious Research octane number ratings because their normal combustion rate in rich mixtures is so high that it affects knockmeter like conventional detonation; problem can be reduced if rule is adopted never to rate fuels at mixture strengths richer than that at which bracketing primary reference fuels give their maximum knock; rule would not exclude any effects of "road" interest.

Abnormal Combustion Problems in Gasoline Engines, B. M. STURGIS. Paper No. 293A. Attempt made by

continued on p. 133

You can select Hi-Torque brakes in standard sizes and mountings for your heavy-duty vehicles

B.F.Goodrich Hi-Torque brakes are now available in seven basic sizes, from 17¼″ x 4″ to 26″ x 7″, with a variety of mounting designs. Brake actuation can be provided by either air-over-hydraulic, or direct hydraulic power. Thus you can use these brakes in your vehicles with a minimum of design change.

Hi-Torque brakes are now supplied as original equipment on a wide range of heavyweight vehicles: big dump trucks, tractor-scrapers, coal haulers, mine trucks, and other special vehicles. They provide up to 125,000 pounds feet of braking torque per brake in a smaller sized "package" than any other brakes. Hi-Torque brakes cut stopping distance approximately in half, compared to conventional two-shoe brakes tested on identical vehicles and loads.

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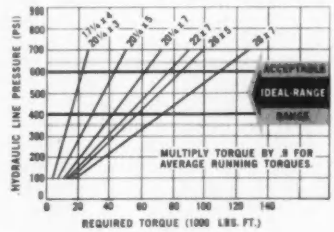
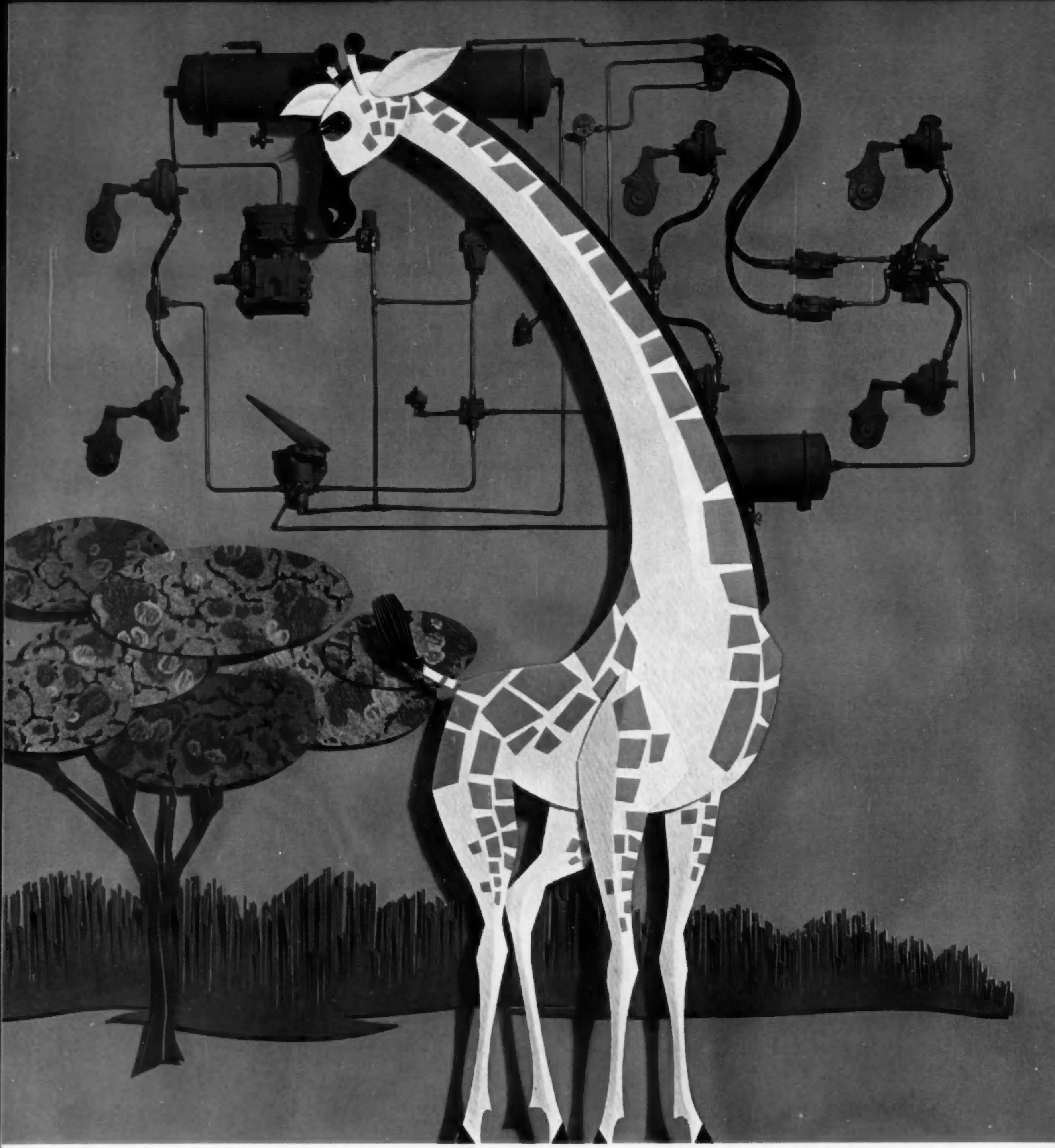


Typical data available on pressure-torque characteristics helps you in selection of the right Hi-Torque brakes for today's growing vehicle loads.

B.F.Goodrich Hi-Torque brakes



HIGHEST STANDARDS IN AIR BRAKES, TOO. The giraffe's built-in ability to reach high is unique among animals. Similarly, among air brakes, Bendix-Westinghouse systems have a capability and reputation unique in the industry for reaching highest performance standards. Among the reasons: dependable design; system-engineered components that give balanced performance; exacting manufacturing standards; and closely maintained quality control. Another bonus benefit: The reputation for customer service earned by Bendix-Westinghouse through 38 years of close and constant association with the transport industry. That's why you can buy with complete confidence when you specify Bendix-Westinghouse Air Brakes—the product and name you can trust.

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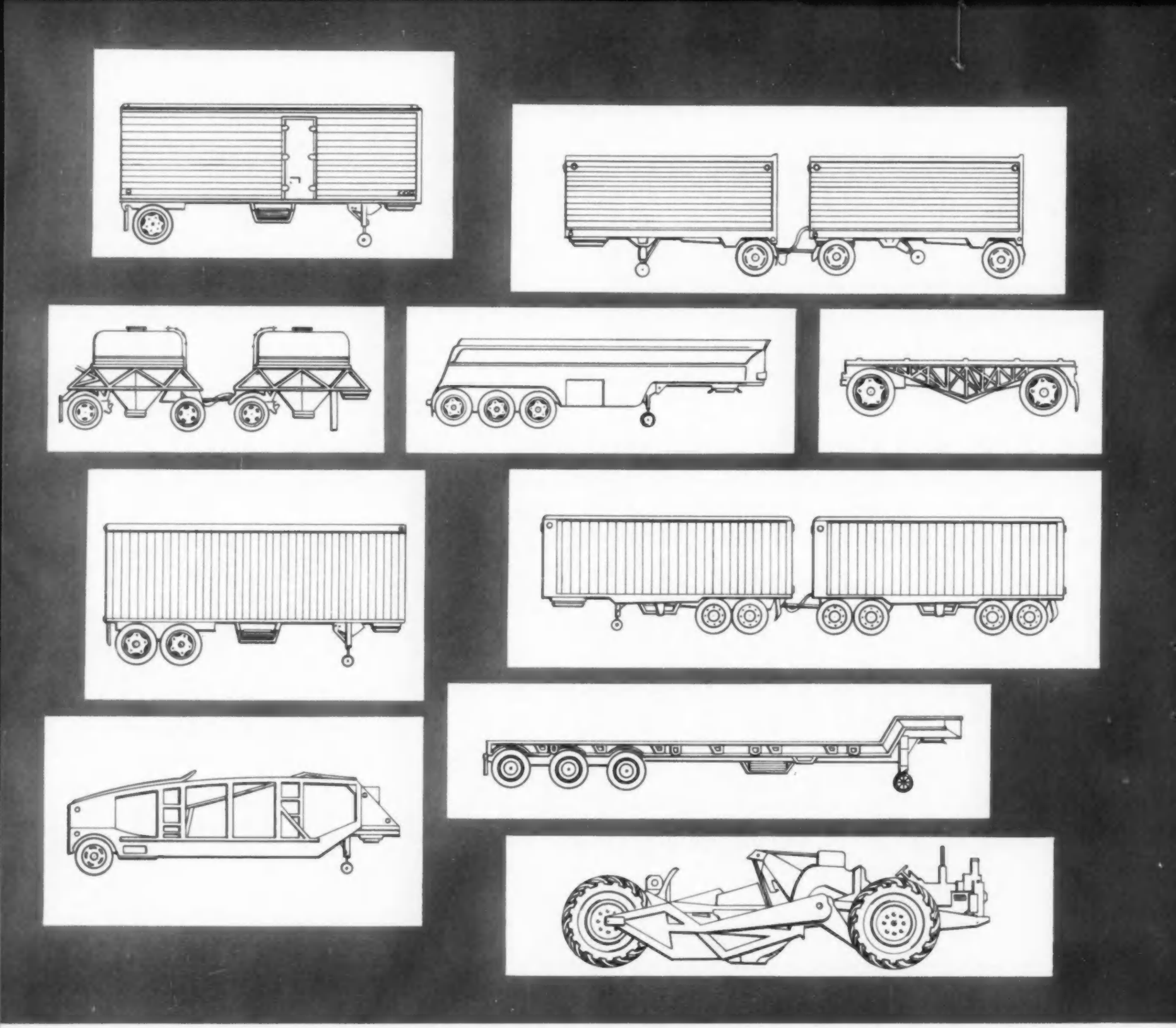

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meets every kind of trailer Air Brake need

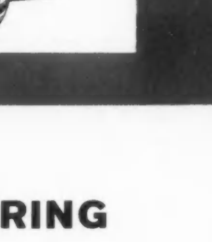
When specifying trailer air brakes, here are three important facts worth keeping in mind.

First, there's a complete Bendix-Westinghouse Air Brake System available for every type and make of trailer.

Second, Bendix-Westinghouse brakes are system-engineered so that all components work together best for maximum operating dependability and economy.

Third, these braking systems are designed for balanced performance with Bendix-Westinghouse tractor braking systems—together forming an unbeatable braking "team".

Still another Bendix-Westinghouse "plus" is the new RE-4 Relay Emergency Valve. By providing constant output over a wide temperature range and assuring immediate pressure balance of tractor and trailer braking systems, it provides a new standard of safety and performance. And it's simple to maintain because its emergency piston assembly can be replaced in minutes. Now available in exchange for your present relay emergency valves on a low-cost changeover plan. See your authorized distributor.



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Briefs of SAE PAPERS

continued from p. 127

Petroleum Laboratory of E. I. du Pont de Nemours & Co. to correlate existing information and to point out areas to explore before adequate solutions to existing and future problems can be devised; four types of surface ignition, three possible mechanisms by which deposit particle or surface could get hot enough to ignite combustion chamber charge, and factors controlling ignition process; problems related to autoignition in engines. 81 refs.

Good Diesel Fuels and Lubricants Don't "Just Happen", J. PEET. Paper No. S280. Properties of fuels and lubricants important in assuring proper performance and efficiency of diesel engines are discussed; physical inspections for fuels of importance from standpoint of performance and efficiency are cetane number, volatility, sulphur, and gravity; methods used to assure acceptable levels of these properties: sulphur dioxide extraction, acid treating, sweetening operations, and drying; minimum lubricating oil requirements; various lube-finishing processes.

GROUND VEHICLES

Fuel Filter Test Methods — TPS-1. An extensive report of new testing techniques in evaluating fuel filter capacity, pressure drop, and volume flow — and evaluation of media migration.

Major Problems of Overhead Rapid Transit, L. E. CHADENSON, J. L. BOURGTON. Paper No. 266C. Effects made by French constructors to overcome noise problems and encumbrance of structures; use of Michelet metal core tires, built for Paris underground system, led to concept of vehicles suspended from their trucks running inside guiding and rolling track, constructed like box girder with 25 to 30 m spans, resting on supports of 30 to 31 in. in diam.; suspended monorail with suspensions in central vertical plane of longitudinal symmetry of car bodies uses conventional railways switches.

Autoline — Missing Link in City to City Transportation, A. A. ATWELL, R. F. McLEAN. Paper No. 266D. Transportation system is outlined containing concept of dual modes; in one mode, private vehicle is operated on streets in conventional fashion; in addition, it can be placed in high speed automatically controlled network on

continued on p. 136

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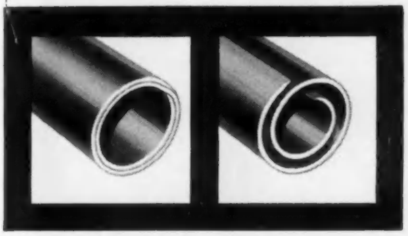

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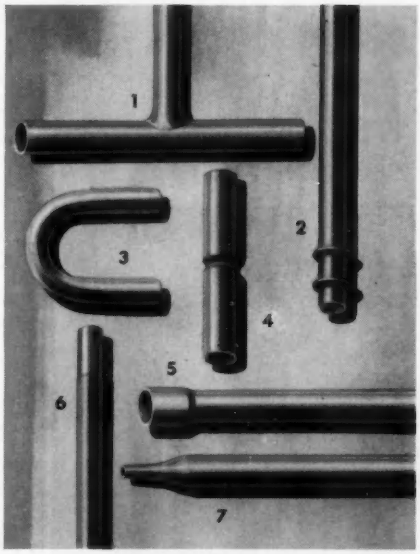

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Briefs of SAE PAPERS

continued from p. 133

highway to achieve cruise speeds two to three times greater than at present; overall cost possibilities and advantages of new system over existing transportation are developed.

2-D Mannikin — The Inside Story, S. P. GEOFFREY. Paper No. 267A. Anthropometric data available were combined into one report for specific application to automobile seating; new bone length studies reviewed and X-ray techniques employed; result was seated male 2-dimensional side view template, referred to as "Oscar", complete with flesh line contours and effective bone link pivot points; tabulation of resulting data for stature and weight percentile distribution; tabulated standard deviations shown on chart.

General Motors Comfort Dimensioning System, V. D. KAPTUR, Jr., M. C. MYAL. Paper No. 267B. Human engineering principles for automobile passenger compartments and principles of concept of dimensioning to human; application of design limits to two- and three-dimensional tools is evaluated; review of comfort dimensioning practices followed by General Motors and description of car checking procedure.

How Can Physiologist Contribute to Improvement of Automobile Seats, F. PICARD, A. WISNER. Paper No. 267C. Efforts made in construction of seats so that poor posture, unpleasant riding or violent shocks can be avoided; knowledge, variability and seat and dimensional structure of driver's post; how upholstery of seat plays part in comfort by correct distribution of pressure on areas of support and in constituting part of suspension system of car; dynamic properties of polyurethane foams; seat as element of safety.

Devolopment of Chrysler Automotive Centrifugal Compressor, G. A. BALL, A. H. BELL, L. B. MANN. Paper No. 268E. Technical development and engineering techniques used to achieve program objectives; initial design of compressor contained areas where 1-dimensional flow was considered adequate; as development proceeded, it became necessary to extend analyses to 3-dimensional basis; primary criterion in designing impeller was division of static pressure rise between impeller and diffuser; mechanical considerations involved; intake development.

Role of Compressor in Limiting Automotive Gas Turbine Acceleration, C. A. AMANN, G. E. NORDENSON. Paper No. 268F. Examination of factors affecting engine acceleration; early experience made with 225-hp General Motors GT-305 engine showed that avoidance of compressor surge during gasifier acceleration was real problem in initial development; study of problem area and redesign of diffuser; with new diffuser used in 13 engines delivered for field evaluation no problems with compressor surge during acceleration were experienced.

Compression Temperatures in Diesel Engines Under Starting Conditions, W. E. MEYER, J. J. DeCAROLIS. Paper No. 272A. In study of suitability of fine wire thermocouples for determining peak compression temperatures two methods of correcting for temperature lag were applied to indicated peak temperatures; measurements made show effect of different variables on peak temperatures attained during cranking; it is found that peak temperatures obtained by means of thermocouples are reliable indicators of temperatures that determine startability.

Gas Temperatures During Compression in Motored and Fired Diesel Engines, K. C. TSAO, P. S. MYERS, O. A. UYEHARA. Paper No. 272B. Temperatures were measured using infared null technique; compression temperatures were higher in fired than in motored engine; ignition-delay data obtained and correlated; expression for ignition delay as function of pressure, temperature, and engine rpm; data comparing peak temperatures measured with 0.0008-in. thermocouple and infrared null technique show time lag in thermocouple of 3–4 msec.

Swimmability Features of XM521 Truck, T. R. GONDERT, T. J. BISCHOFF. Paper No. 273A. Concept and design criteria of small truck-like vehicle which must enter or leave water from 60% slope, enter from 4-ft vertical drop, attain reasonable water speed, respond well to steering, resist tipping and sinking; design of hull and body structure providing coaming around driver's compartment to protect him from water and to shield cargo area; drive arrangement incorporating twin propeller drive; specifications of drive system.

Design of Bonded Body-Frame Structure for XM521 Experimental Military Truck, S. J. PEARSON, T. J. BISCHOFF. Paper No. 273B. Scope and design objectives of perfectly sealed body-frame structure which would have sufficient buoyancy to allow floating and water operation with 5000-lb payload; use of aluminum bonded panels having thin faces and honeycomb cores; construction of core and skin selection; adhesives and banding procedures used; types of loading encountered; summary of features.

Design of New Experimental Truck, Cargo, 2-½ Ton, XM521, T. J. BISCHOFF. Paper No. 273C. Objective of program, principal features of truck and performance requirements; power train consists of 4-cyl air cooled opposed aluminum engine coupled to 4-speed synchromesh transmission located directly under cab area; description and illustration of each pertinent design area relating to body frame, transmission, brakes, steering system, fuel tank, etc; water propulsion.

Digital Computer Utilization in Design of Experimental Truck, 2-½-Ton XM521 at Detroit Arsenal, R. D. ARNO, T. J. BISCHOFF. Paper No. T46. Analysis of truck acceleration performance using Datatron system; establishing vehicle velocity, distance traveled, time to travel, wheel torque, tractive effort, rolling resistance, drawbar pull, and acceleration for each transmission and transfer-case gear position; determination of optimum engine transmission combination with desirable followup gear ratios that provide best compliance with military requirements; mathematical model.

Characteristics of Batteries for Small Engine Applications, J. F. SCHAEFFER. Paper No. 276A. Electrical characteristics of several types of small batteries designed for starting applications on small ½ to 10-hp engines are reviewed, with comparison made between these batteries and those designed for motorcycle service; relationship between characteristics and performance in driving engine are shown; factors in charging and general handling of batteries.

Excited Field Brushless Flywheel Alternator for Outboard Engines, R. L. LARSON. Paper No. 276B. Homopolar inductor alternator was selected by Delco-Remy Div. for further development; details of alternator capable of being regulated accurately by transistorized voltage regulator, which has contact-life expectancy as long as life of engine; schematic wiring diagram and performance.

Flywheel Alternators with Ferromagnetic Wheels, W. O. HENSCHKE. Paper No. 276C. Details of alternator, developed by R. E. Phelon Co., featuring inherent self regulation, elimination of sliding contacts and possible ignition combinations; static rectifiers permit flexibility in location of engine components and simplify control functions; necessary inertia of flywheel can be combined with generating device; ignition system may be incorporated; construction and performance characteristics; small industrial and marine engine applications.

Flywheel Alternators for Small Engine Applications, G. A. GUERNSEY. Paper No. 276D. Approach taken by Globe-Union Inc. in designing alternators for nonautomotive applications; flywheel alternator for motor scooters has six magnets providing single-spark magneto ignition for engine operation, lighting or battery charging output; magneto alternator which provides ignition and battery charging for ride-on lawnmower has stator plate pilots on engine and coils to furnish single-spark magneto ignition and a-c output rectified for battery charging; 12-pole permanent magnet, single-phase alternator for outboard motors.

Unique Characteristics of Radial Wire Tire, H. B. HINDEN. Paper No. 278A. U. S. Rubber Co. solved equations for inflated tire shapes and programmed these for computer use which makes it possible to anticipate exact shape which tire of particular cord length and angle will assume on inflation; introduction of tire constraint has permitted use of tire cord angles previously unacceptable; characteristics from tire cord oriented in radial direction are enumerated; traction performance compared to conventional angle, textile tires.

Steelcord Tire and Wire Production Techniques, A. F. WEBER. Paper No. 278B. Technique used in manufacturing cord itself at Firestone Tire & Rubber Co. include rod selection, patenting, cleaning, brass plating, and wire drawing; details of steel cord and tire construction; tire assembly; special techniques developed for curing of Steelcord radial ply tire.

Field Results and Field Problems with Belted Type Truck Tires, F. S. KINE. Paper No. 278C. Goodyear tire is designed for over highway use but can be used equally as well on fronts, drives and trailer positions on over road rigs; improvement obtained in tread wearing quality; other advantages resulting in fuel economy, softer ride, puncture resistance and improved traction; comparison with conventional tire shows that belted one runs up to 100 F. cooler, thus improving rate of wear and lessening chance for blowouts.

Initiation and Some Controlling Parameters of Combustion in Automobile Engine, J. S. CLARK. Paper No. 279A. Work carried out in England to inquire more deeply into phenomena of combustion, and to show how added knowledge can be used to promote better future designs; intake and cylinder airflow considerations; mixture formation; ignition in diesel and in gasoline engine; application of chemical kinetics; future research. 39 refs. Paper will be presented before Instn. Mech. Engrs., London.

Effects of Cylinder Size on Detonation and Octane Requirement, C. F. TAYLOR. Paper No. 279B. Engines used are geometrically similar single-cylinder engines installed in Sloan Laboratories for Aircraft and Automotive Engines at MIT in 1948; test procedure used; work is concerned with knock-limited indicated mean

continued on p. 138

Briefs of SAE PAPERS

continued from p. 137

effective pressure (klimep) vs bore for three separate investigations; results obtained with tests at same rpm, runs with temperature measurements, and cylinder-size effects in practice; tables and curves.

Trends in Manufacturing of Corrosion Proof Automobile Bodies, H. D. VAN SCIVER. Paper No. 281A. Metallurgical and manufacturing trends are examined to show progress made in improving corrosion resistance of conventional bodies; forming, welding and adhesive bonding, advantages and limitations of each process; it is concluded that breakthrough to actual production of corrosion proof body will start with stylist and continue with structural designers and manufacturing process groups.

Improved Corrosion Resistance for Automobile Bodies, S. K. COBURN, J. W. STEWART, R. B. MEARS. Paper No. 281B. Methods used comprise selection of alloy that reacts with environment to form surface compounds as protective barrier, use of applied protective coatings, and cathodic protection; corrosion resistance of various steels; atmospheric corrosion resistance of painted steel; current methods of corrosion prevention; role of design in efforts to eliminate potentially troublesome areas should be part of engineering and styling requirements.

Generator and Battery System Evaluation in City Traffic, E. J. NEWILL. Paper No. 282A. Winter night city traffic conditions are used as basis for evaluation of generator and battery performance on passenger car applications; evalution of new generator and battery system for existing vehicle can be accomplished by comparing programmed test results for system to be studied with similar test results for systems with known field service history; use of simulated city traffic tests guides design of battery and generator system components to be matched for individual applications.

Chrysler Alternator, A. F. JILBERT. Paper No. 282B. Summary of research work leading to alternator program to develop quiet a-c generator with cost comparable to d-c generator; selection of 3-phase full wave alternator and basic design of X2910 production alternator; ground diodes are pressed directly in rectifier end casting; individual diodes are pressed into heat sink, insulated from end casting by mica; noise program carried out; essential parts of voltage regulator which consists of only one unit.

Rectifiers for Automotive Alternator Systems, J. R. WELTY. Paper No. 282C. Design features implied by requirement are considered with respect to problem of heat removal in three areas: thermal resistance from junction to case in rectifier, from case to heat sink, and resistance between heat sink and ambient air; it is shown that cooling system of alternator should be designed to limit heat sink temperature to 135 C. or 280 F., under worst ambient conditions encountered in operation; steps in manufacturing process; speculations made with respect to expected future changes.

Trucks as Influenced by Super Highway System, J. C. WAGNER. Paper No. 284B. Interplay of influence between trucks and roads and projections made with regard to economic conditions, population growth and Interstate Highway System for next 15 yr; truck trains are foreseen for long hauls on interstate system; reference made to double-bottom unit, operating experimentally on Kansas, Illinois, Ohio, New York and Massachusetts turnpikes; power plant trends, diesel engines and gas turbines; concept of containerization combined with truck trains.

NSU-Wankel Rotating Combustion Engine, W. G. FROEDE. Paper No. 288A. Development and principle of engine based on certain geometrical relations between trochoidal curves and corresponding envelope configurations; comparison between rotary combustion and reciprocating engine; present status of development and layout, performance and applications of KKM 250 and KKM 400; main advantages are: no unbalanced inertia forces, simple layout, comprising only two moving parts, minimum overall volume, favorable weight-to-power ratio, and manufacturing by simple methods.

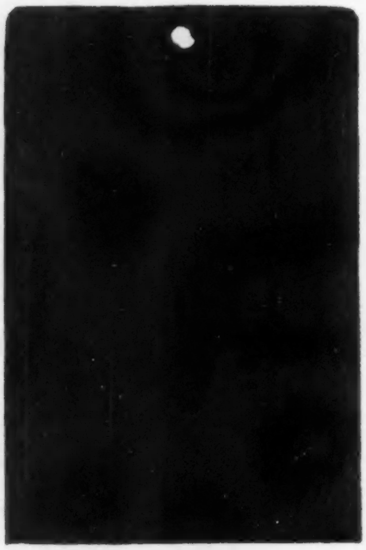
Curtiss-Wright's Developments on Rotating Combustion Engines, M. BENTELE. Paper No. 288B. Although Curtiss-Wright's agreement with NSU and Wankel covers full scope of sizes and configurations of rotating combustion engines, firm concentrated on single rotor KKM type with stationary rotor housing and 3-cornered rotor rotating at ⅓ crankshaft speed; design features and performance data for experimental engine RC6, 4-rotor engine 4RC6, RC19 engine, built to investigate size effect on various engine phenomena; design parameters and test results.

Development of Ford 704 Gas Turbine Engine, I. M. SWATMAN. Paper No. 291A. Cycle selected consists of two stages of compression, resulting in overall pressure ratio of 16:1, with air-to-air intercooling between stages to reduce work, size, and tip speed of h-p

continued on p. 141

WHAT'S NEWS IN ENJAY RESINS FOR SURFACE COATINGS

Alkyd Melamine
After 500 Hours
Salt Spray



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After 700 Hours
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After 700 Hours
Salt Spray

BUTON® 200 Resin offers better corrosion resistance–saves up to 1/3 the cost

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ENJAY CHEMICAL COMPANY

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Briefs of SAE PAPERS

continued from p. 138

compressor; mechanical design, l-p spool, which is turbocharger for engine, intercooler and fan, and h-p spool; turbine is single-stage unit rotating at 37,500 rpm; output shaft is reduced in speed to 4600 rpm by planetary reduction gear; heat exchanger and fuel control system; installation in C-1100 tilt cab truck.

Locomotive Transmission Systems, H. E. MARTIN. Paper No. 291B. Diesel electric and hydraulic transmissions are examined, their similarities and differences pointed out; development of General Motors diesel hydraulic locomotives ranging from 275 to 800 gross hp and 35 to 75 tons; major components and features of various models; comparison of transmission range of electric and hydraulic; it is concluded that unless electric transmission accelerates its rate of improvement, hydraulic will take over increasing amount of locomotive business.

Passenger Riding Comfort Criteria and Methods of Analysing Ride and Vibration Data, H. C. A. van ELDTK THIEME. Paper No. 295A. Paper considers only mechanical vibration problem in frequency region of 0.1–100 cps; comfort criteria obtained from objective and subjective tests; methods and results of analyzing vibration data of ride comfort measurements carried out on vehicles in motion by Vehicle Research Laboratory, Technological Univ., Delft, Holland; recording devices used and analysis of magnetic tape records; survey of results obtained. 24 refs.

Turbine Driven Amphibians — New Trend in Fast Assault Craft, K. A. AUSTIN, L. S. VOTRE. Paper No. S270. Developments to be used in military landing operation capable of boosting amphibious tactics are exploitation of hydrofoils, ground effect machines, and rugged transporation gas turbines; new vehicle power requirement, characteristics of 1000-hp Lycoming T53 industrial and marine turbine developed; studies and experiments with modified World War II DUKW high water speed wheeled amphibious vehicle and "Hydrophibian", 5-ton 4 × 4 gas turbine powered vehicle.

Turbocharged Two-Stroke Outboard Propulsion Unit, J. L. DOOLEY, J. E. LEACH, JR. Paper No. S271. Design considerations of 4-cyl radial engine, developed by McCulloch Corp., having bore and stroke of 3.25 × 2.72 in. and rating of 120 bhp at 4500 rpm; outstanding features are fuel injection directly into cylinder, turbosupercharging scavenging to provide air delivery ratio up to 1.5 at air box pressure of 60 in. Hg abs, and reentry compressor in series flow with turbocompressor; components and specifications.

1961 Lincoln Continental Engine — New Concept of Powerplant Reliability, J. M. STOUT. Paper No. S272. Comprehensive engineering program at Ford to improve durability and reliability of Lincoln Continental engine to point where warranty period could be raised to 24 months or 24,000 miles, including discussion of design changes, engineering tests, production changes, and factory break-in of engine.

Recent Developments in Air, Lubricating Oil, Hydraulic Oil and Fuel Oil Filtration, F. R. GRUNER, H. L. FORMAN. Paper No. S274. Improvements made in filters for internal combustion engine with respect to filter life and efficiency, materials of construction affecting strength, and methods of evaluation; examples of filters for different applications, developed by Purolator Products, Inc., Rahway, N. J.; bench evaluation and field testing, wear and bubble point test.

Potential Passenger Car Powerplants, J. S. WINTRINGHAM. Paper No. S275. Examination of power plants which

continued on p. 142

Briefs of SAE PAPERS

continued from p. 141

should be competitive with respect to size, weight, power, flexibility, economy, manufacturing cost, and general convenience to replace reciprocating gasoline engine; group includes diesel engine, gas turbine, free piston engine, battery power, fuel cell, Stirling engine, and NSU (Curtiss-Wright) rotary engine; it does not appear that any other is likely to replace gasoline engine.

Why Diesels for Small Trucks, J. C. CAMPBELL. Paper No. S277. Basic design of General Motors Series 53 diesels which share common 53-cu in. cylinder size for maximum parts interchangeability; they are built in 2-, 3-, 4-cyl in-line units, and v-type 6-cyl unit; experience shows that there are small truck operations where diesel's operating savings and extra productivity build profits, namely in city-to-city, pickup and delivery, and multistop operations; chart, based on experiences with fleet use of Series 53 diesels shows fuel and maintenance savings per year.

Aluminum Chassis, W. C. WELTMAN, JR. Paper No. S279. Material selection for various components, welding practice.

Mobile Radio, Its Relation to Vehicle Electrical System, Space and Location Requirements, and Some Problems in Mobile Radio Operation and Maintenance, W. C. BAYLIS. Paper No. S283. Relationship of mobile radio communication to motor vehicle electrical system, space requirements, and operation of these systems.

Fuel Economy — What is the Potential? I. N. BISHOP. Paper No. S294. Contends part-load economy of spark-ignition engines might be doubled . . . not by any single invention or development but through concentrated research in many diverse fields; evolutionary not revolutionary. Refers briefly to specific possibilities for improvement.

MATERIALS

Breakthrough in Body Structure Utilizing Glass Fibers, Polymers, and Plastics, R. T. STEVENS, I. J. GUSMAN, I. B. COHEN. Paper No. 274A. Properties of reinforced plastics based upon thermosetting resins and woven or random oriented glass fibers; possible glass reinforced plastics for automobile bodies are examined with reference to concept of product evolution by generations; four generations are shown, last one referring to new transportation modes (GEM, etc).

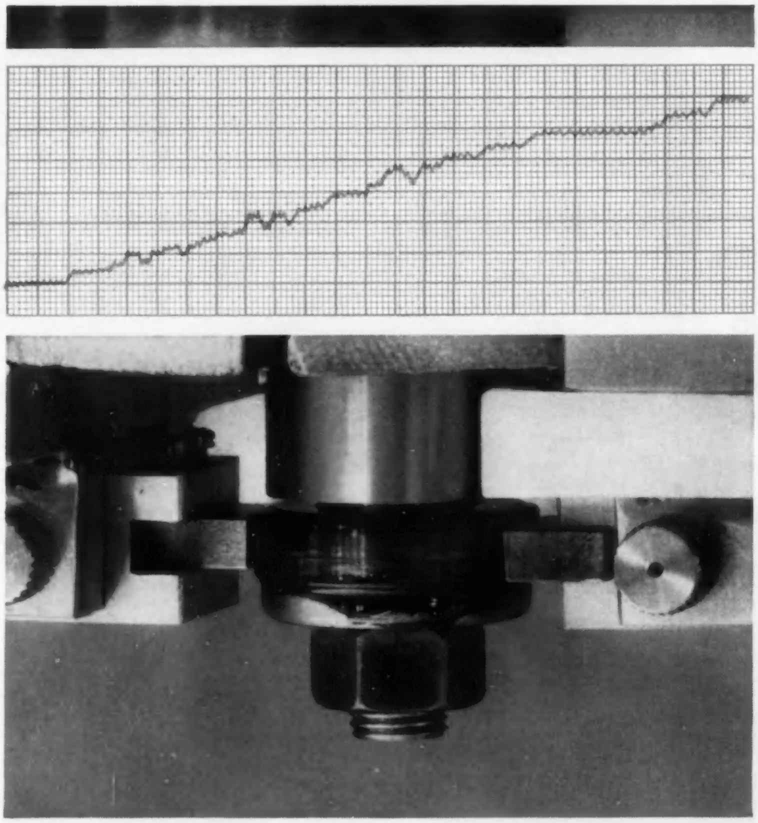
PRODUCTION

Practical Application of Operations Research in Physical Inventory Control, M. R. BRYSON. Paper No. 286A. Study conducted at Duke Univ. to find ways of maintaining with high degree of accuracy records dealing with storage and supply operations of U. S. Government agency of Error Analysis Phase made to discover what caused errors to be injected into records and to devise ways to minimize these; Physical Inventory Phase, to devise method of taking physical inventory to correct record errors once they were in system; method of operation; causes of errors tabulated.

Practical Application of Operations Research in Multiple Level Management, W. IMBRE. Paper No. 286B. Details of computerized integrated planning and control system designed specifically for management of research and development programs and used in Curtiss-Wright Corp.; areas in research and development organizational complex each representing different problem in management planning and control which must be integrated; examples of program planning and control, engineering and shop

continued on p. 147

WE TAKE THE PULSE OF BEARINGS ON TAPE TO MAKE THEM EVEN BETTER!



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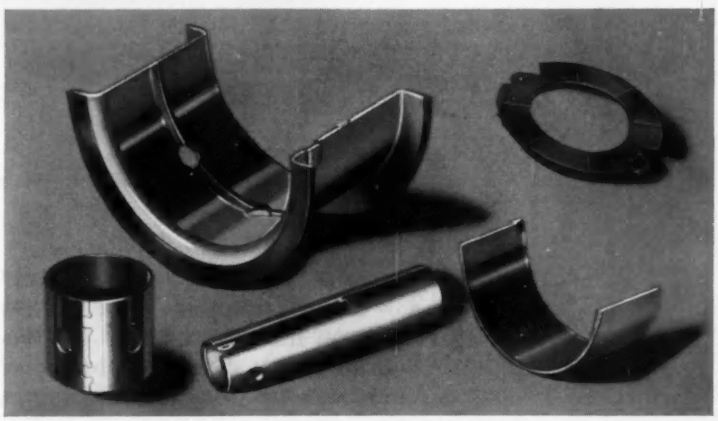

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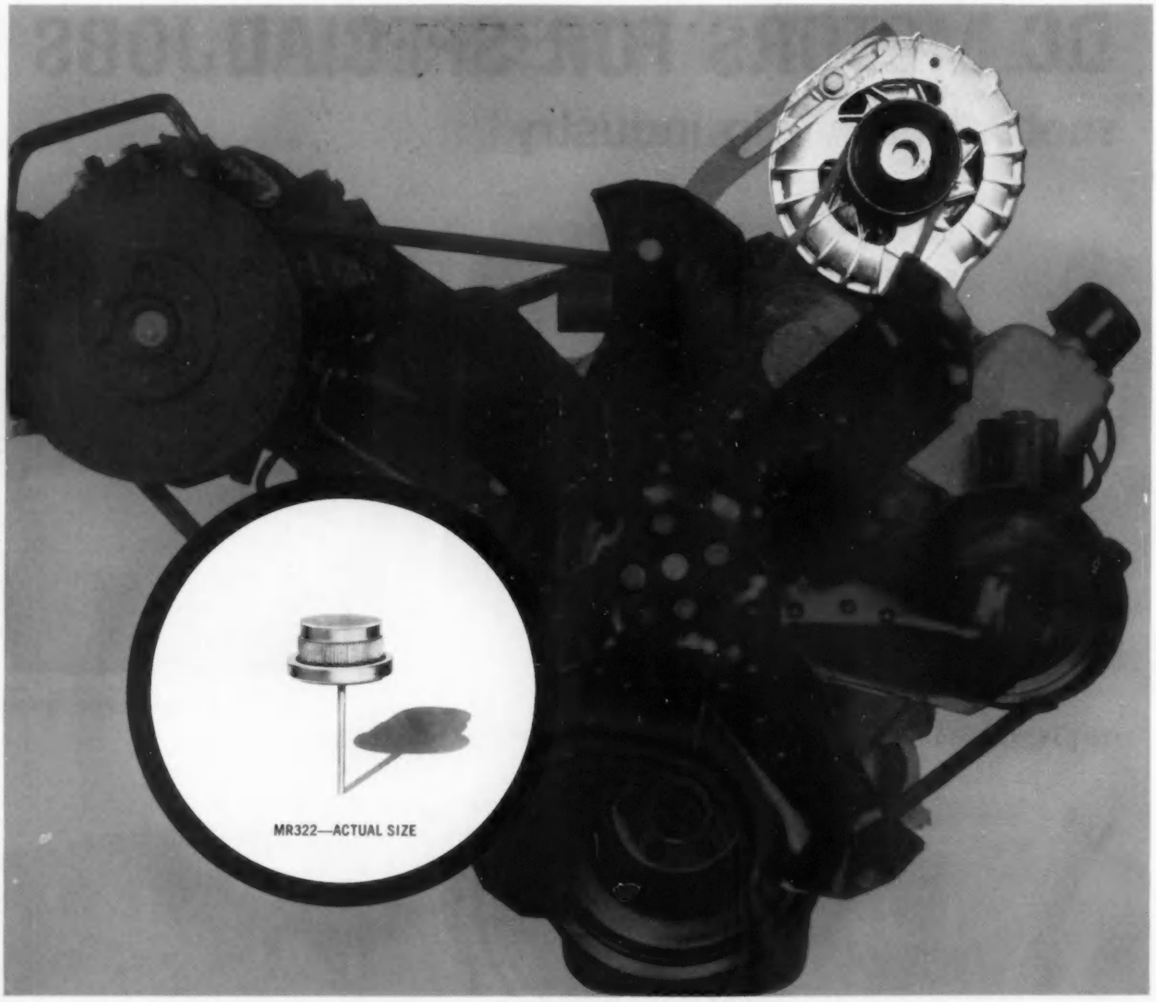

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Briefs of SAE PAPERS

continued from p. 142

area load scheduling, company management control, sample planning and control sheets and sample manpower loading sheets.

UNITS OF MEASUREMENT

Evolution Versus Revolution — Problem of Our Unit-Systems, C. KAYAN. Paper No. 287A. Review of efforts made towards changeover from Anglo-American to Metric system, with particular attention given to MKSA system; 1959 program developed by AAAS entitled Operation SCUDS: Simplification, Clarification, Unification, Decimalization, Standardization; program of action is proposed for United States which is divided into consumer-public aspects, and technological aspects; its provisions are outlined.

Physical Standards and Units of Measurement, R. P. TROWBRIDGE. Paper No. 287B. Subject of conversion to metric system is critically examined and arguments for conversion analyzed; it is concluded that motivations for going metric are insufficient to justify conversion of entire economy; coexistence of two measurement systems will continue for many years to come with increasing understanding of individual applicability for both systems by all concerned.

Significance of Change to Metric System of Mathematics Education, A. W. JACOBSON. Paper No. 287C. In workshops of Detroit Research Inst. for Detroit area teachers, it is agreed that teaching of decimal fractions should begin early; reasons for adoption i.e., trigonometry in calculus and advanced mathematics is based on trigonometry of real numbers, and operation of electronic computers on decimal or binary number systems; cooperation between teachers and industrial leaders; best way for eventual adoption of metric system is to decimalize Anglo-American units of weights and measures.

Metric System and Department of Defense, J. J. RIORDAN, C. J. BRZEZINSKI. Paper No. 287D. Purpose of paper is to identify problems arising in event that metric system of weights and measures were adopted throughout Department of Defense, and to examine modes of planning and action to facilitate conversion; it is concluded that Department must adapt to decisions made in interest of national economy as whole and that it can serve as effective cataytic agent for its wide and expedited adoption, once system is adopted.

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New Members Qualified

These applicants qualified for admission to the Society between Jaunary 22, 1961 and February 22, 1961. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group: Eric Brown (A), Vernon George Seadon (A).

Atlanta Section: W. P. Frech (M), A. W. (Ted) Taggart (M).

Baltimore Section: Abraham G. Emanuel (M).

British Columbia Section: Donald Arthur Brundrett (J).

Buffalo Section: Michael Francis Doyle (M), Kenneth Franklin Lingg (M).

Central Illinois Section: Benny Ballheimer (A), Ernest Henry Grieme (A), Stanley L. Kerker (J), Theodore Mathew Kero (J), Donald Elmer Lull (J), James O. Machlan (J), Raymond Eugene Schuler (J).

Chicago Section: William V. Burke (A), Clifford W. Hager (A), Charles Michael Neugebauer (M), Philip Otho Schafer (M).

Cincinnati Section: Ernest Hugh Bradley (A), Russell E. Single (A).

Cleveland Section: John W. Brodhacker (M), Wells E. Ellis (M), Paul Nierman Jaroch (J), Robert P. Klenner (A), Steven Ottokar Luzsicza (M), Edgar Gauch Parks, Jr. (J), Anthony John Riccio (J), Charles Francis Walton (M).

Dayton Section: Julian N. Andrews (A), Roland Lee Kesler (J).

Detroit Section: Werner Kurt Baumgartner (J), Edward Richard Betz (J), Albert Francis Cassidy (M), Paul Martin Chellberg (J), Lawrence Hume Chenault (J), DeWitt W. Cooper (J), Donald A. Darnell (M), Robert Allen Darovich (A), Robert Francis Dillon (M), Richard Marvin DuBois (J), Richard B. Gould (M), William G. Holdman (M), Peter Edgar Hoyal (A), Tadeusz Idzikowski (M), Robert E. Kolp (A), Eugene Donald Konrek (A), Milton A. Kraska (M), Stephen J. Linsenmeyer (A), Louie Jackson Lipp (J), Gilbert Thomas Lyon (A), Alexander Hing Mark (M), Ronald C. Mason (A), Robert Frederick Mettler (M), Daniel Henry Moir (M), Dan A. Montgomery (J), Franklin Delano Obermeyer (J), Theodore Padzensky (J), Albert Frederick Schmaltz (A), Louis Jerome Sciez (J), Gene L. Scofield (J), Richard Kenneth Shier (J), Charles E. Sloan (A), Thomas Edward Stuck (M), Charles E. Sweet, Jr. (J), Edward S. Wellock (M).

Hawaii Section: Richmond Kaliko Ellis, Jr. (J), Bruce Noboru Takamine (A).

Indiana Section: Dan C. Fuller (M), Donald R. Vance (M), Tracy H. Wolfe (A).

Kansas City Section: Lawrence Conrad Bender (M).

Metropolitan Section: Larry John Fauci (A), Charles Stuart Hale (A), Gerald Kopelman (A), John George Merkel (J), John J. Pepas (J), Edward John Roche (M).

Mid-Michigan Section: Robert Russell Haist (M), Arthur William Henke (J), Dan R. Kimberlin (J), Dale A. Marek (M).

Milwaukee Section: Thomas Henry Hock (J), Milan Petrovich (M), David Eugene Schuh (J), Richard Harold Shafer (J), James Walsh (A).

Montreal Section: Claude Coudry (J), Jacques Donato (J), Roy Randall (M).

continued on p. 151

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Rochester-GM Carburetors are tailor-made for maximum performance and economy

From pick-up to peak performance . . . Rochester-GM Carburetors are tailored to the exact requirements of these famous power plants. These ultra-precision carburetors help deliver maximum mileage and rapid response.

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New Members Qualified

continued from p. 149

New England Section: Charles Richard Kimball (A), Allen H. Maynard (A), Charles H. Murphy (A), Frederick Daniel Rugg (A).

Northern California Section: George Urban Brennan (A), Kenneth Le Roy Eckhardt (J), Bertram Jonathan Leigh (M), Peter Francis Melia (J), Robert Palmer Miller (J), Fernando Jose Munoz (M).

Northwest Section: Douglas Earl Miller (J), Vernon H. Salisbury (M).

Ontario Section: William E. Austin (A), Clayton G. Busher (A), Edward W. Castle (M), Russell S. Kenerson (M), Donald Alexander Paterson (A), Reginald B. Spenser (A), Robert Weir (M).

Oregon Section: Louise Sullivan (A).

Philadelphia Section: Lawrence James Bogdon (J), Donald N. Meyers (M), Carl Jacob Schreiner (A).

Pittsburgh Section: James B. Hill (M), Robert J. Walter (M).

Rockford-Beloit Section: Fred R. Fago (M), James H. Fraser (J).

St. Louis Section: Thomas Dale Bell (J), Clarence Delmar Hicks (A).

South Texas Section: Paul Neilson Howell (M).

Southern California Section: Obed Bobbitt (M), Boris Borisoff (M), Larry Lee Brookhart (J), Louis C. Carlin (J), Iwao Ishimizu (J), Michael William Kieklak (J).

Southern New England Section: Thomas D. Lawton (M).

Spokane-Intermountain Section: Terry Lee Prafke (J).

Texas Gulf Section: Ivy B. Langford (A).

Washington Section: Harvey Burwell Bennett (M).

Outside Section Territroy: Ralph G. Cook (M), Robert Garry Lawrence (J), Mark W. Lechtenberg (M), Joseph W. Liggett (M), Alfred L. Neuhoff (M), Marshall D. Sawdey (M), Robert Lloyd Schmidt (J), Harlod M. Schneider, Jr. (J), Thaddeus J. Staniewicz (M).

Foreign: Sayed Bayoumi (A), Egypt; J. Paul Cho (M), Indonesia; Kasi Iyer Krishnan J), India; Karl Wilhelm Maier (M), Germany; Hardarshan Singh Mejie (J), India.

Applications Received

The applications for membership received between January 22, 1961 and February 22, 1961 are listed below.

Alberta Group: Harlod Lynford Fraser

British Columbia Section: Robert Sqvair

Buffalo Section: L. J. McLaughlin, Frank J. Terkoski

Central Illinois Section: Robert Edward Emmert

Chicago Section: William James Bowler, Leon N. Skan, Vernon Crocker Judd, Stephen David Napier, Jack N. Sylvester

Cincinnati Section: Charles Taylor Hamilton

continued on p. 152

Applications Received

continued from p. 151

Cleveland Section: Arnold F. Buchholz, Joseph Michael Homitch, Herbert Ray Lilley, Charles I. Taggart, Edward T. Vitcha

Colorado Section: Reginald Douglas Waite

Dayton Section: John R. English Robert Hall, Lloyd Delbert Williams

Detroit Section: Robert L. Adams, John Hugh Alexander, Randall Edward Beinke, Robert Edward Brackett, Richard Ludwig Branstner, William Frederick Ralph Briscoe, Charles Phillip Brown, T. A. Chapekis, Harry Henderson Chapman, Raymond Marshall Chitwood, George W. Code, Howard John Daenzer, C. A. Degucz, Edgar Siling Eckel, Robert Evans, Milton James Gardiner, Robert William Gillison, Allen Lowell Goody, Donald Wayne Gorrell, Anthony B. Hanson, William Charles Herman, Donald D. Hurd, Norman John Kaarre, Nicholas Kenjoski, Richard F. Kienle, Gene Louis Leithauser, Robert Charles Liem, James C. Louton, Jr., Anthony J. Maranowski, James August Marcedant, William John Martin II, George Amos Miller, Herman E. Mozer, Robert R. Owen, Clement James Roberts, John D. Rogowski, Harley M. Selling, John Edward Sheffield, William H. Sink, Harold Peter Snider, Chris James Spaseff, William Carl Stuef, Donald Robert Taylor, Leo Robert Toomajian, Jr., Gerald A. White, Lawrence A. Waterhouse, Arthur Zaske, Jr.

Fort Wayne Section: Jan M. Smith

Indiana Section: James Parker Gale, Henry A. Hawken, Robert S. Long, James David McGraw

Kansas City Section: E. R. Howell, David Lloyd Thomas

Metropolitan Section: A. John Cummings, Henry Joseph Goffi, Irwin Gray, William Charles Hollopeter, Edward Clark Kenyon, Theodore Calvin Larson, John Carlisle Maclay, William M. Morrison, Dalton George Neudecker, Richard Donald Norton, Odif Podell, Jeremy Fisher Stead, Cyrus Henry Thomas

Mid-Michigan Section: Kenneth Alfred Aho, Louis N. Capatanos, Alfred H. Ellinwood, Ronald Lee Harris, Bruce P. Henderson, Wilbur E. Johnson, Don A. Miller, Robert W. Truxell

Milwaukee Section: Roshan Lal Kochhar, Harold Melvin Nofzinger, Marvin George Pribyl

Montreal Section: James Nicolson Beaton, Roland Dore, Lionel L. Reeves

continued on p. 154

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Applications Received

continued from p. 152

Northern California Section: Arthur James Giles, Andrew K. Nielsen, Gerald Joseph Rohwein

Northwest Section: Paul Owen Mehner, George French Williams

Ontario Section: Oliver Robert Bosso, Jr., Gerben Hylke DeJong, Francis Laszlo Janosi, Alfred Jacques Lantagne, Borge Rommelhof Reimer, William Edward Silburn, Ellis Joseph Sudding

Oregon Section: L. B. Culley, Cresson James Baxter, Jr.

Philadelphia Section: Thomas Alfred Marshall, Jr.

Pittsburgh Section: E. G. Delestienne, J. Warren Stewart, John Howard Weise, Jr.

Rockford-Beloit Section: William H. Shinn

St. Louis Section: Harold Edward McCormick

Southern Texas Group: Larry Lester Bowers, Leonard Monroe DeMasters, Richard Orville Pearson

Southern California Section: Frederick Smith Detwiler, Don C. Lougheed, Donald Gene MacGregor, Charles Milton Micheli, Robert Ray Myers, Raymond Charles Rogers, Elmer Francis Ward

Texas Gulf Coast Section: H. D. Graf, Jr., Gordon Koehl Morgan, Jr.

Twin City Section: Donald E. Glesmann

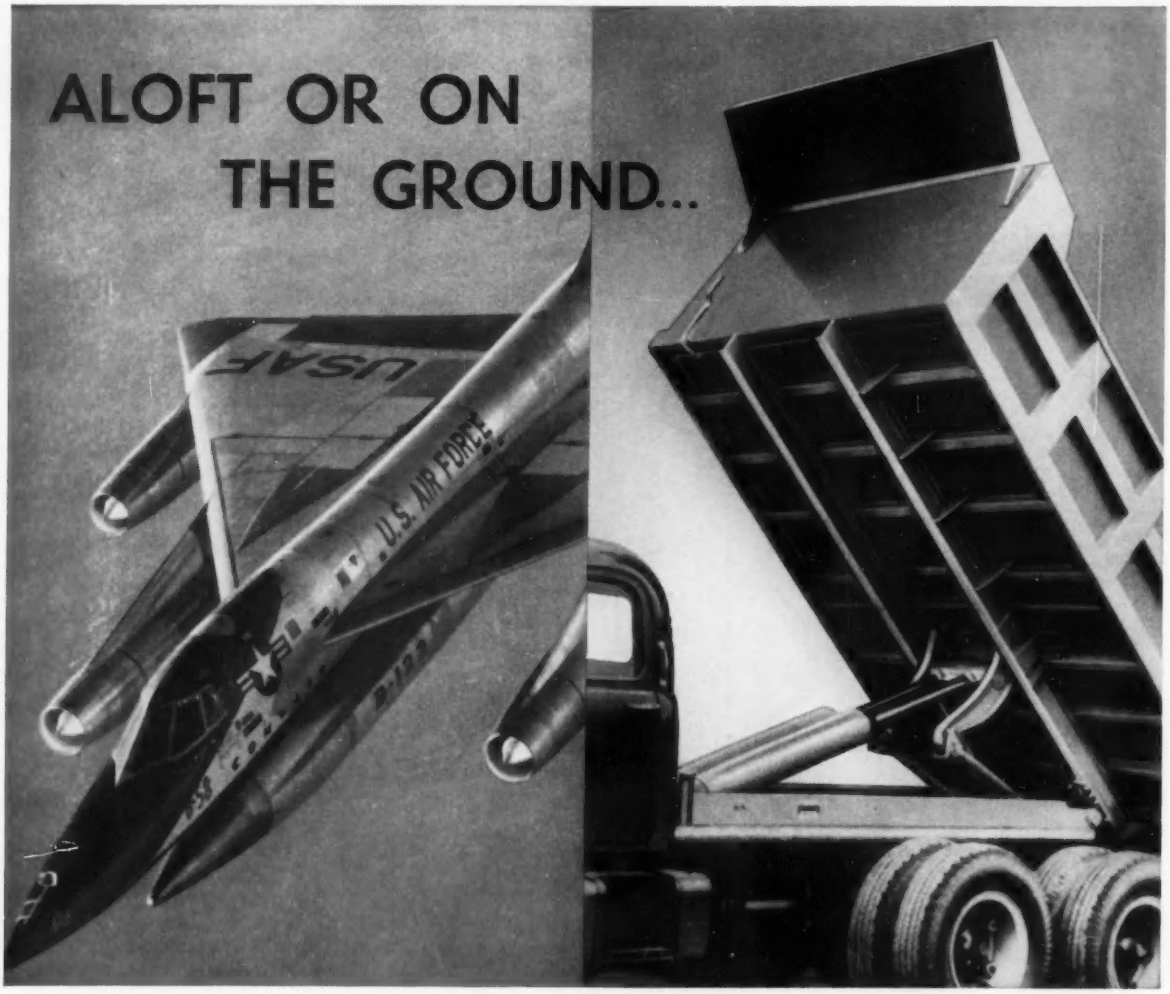
Washington Section: Wilson Cross Shepheard, Richard P. White

Western Michigan Section: Cecil Warren Van Alsburg, Francis Edwin Northon

Williamsport Group: Martin Alperstein

Outside Section Territory: James Thomas McLaughlin, Malcolm Asbury Setphens, Herman I. Wilson

Foreign: Frank App, Jr., Saudi Arabia; John William Bryant, England; Patrick Gavan Connolly, Argentina; Gerard Mervyn Cutler, England; Enrique Antonio D'Acosta, Mexico; Gavin Frederick Hancock, Australia, Virgilio F. Ilagan, Philippines; Francesco Lanzara, Italy; Melville Frederick Mottau, Ceylon; Darayes Norshirwan Pestonji, India; Manohar Keshav Phadke, India; Nagarata Rao Raghavendra Rao, India; Franz Johef Von Bomhard, West Germany; Hugh Reid Waddell, Australia



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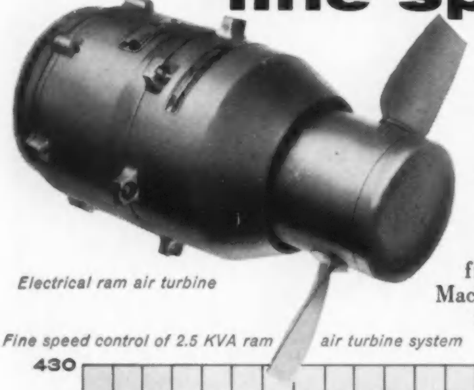

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Hydraulic ram air turbine

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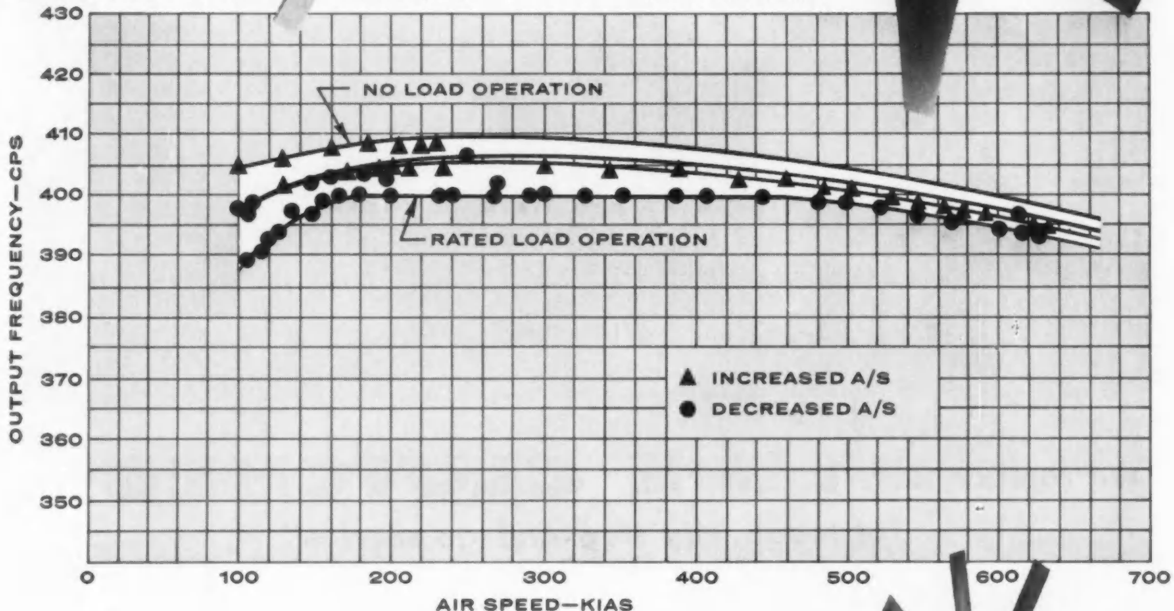

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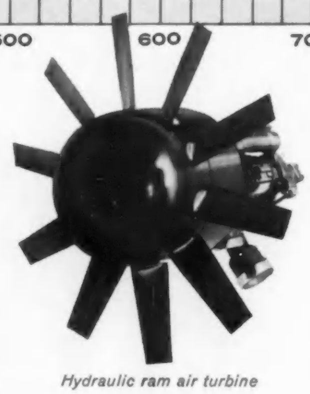

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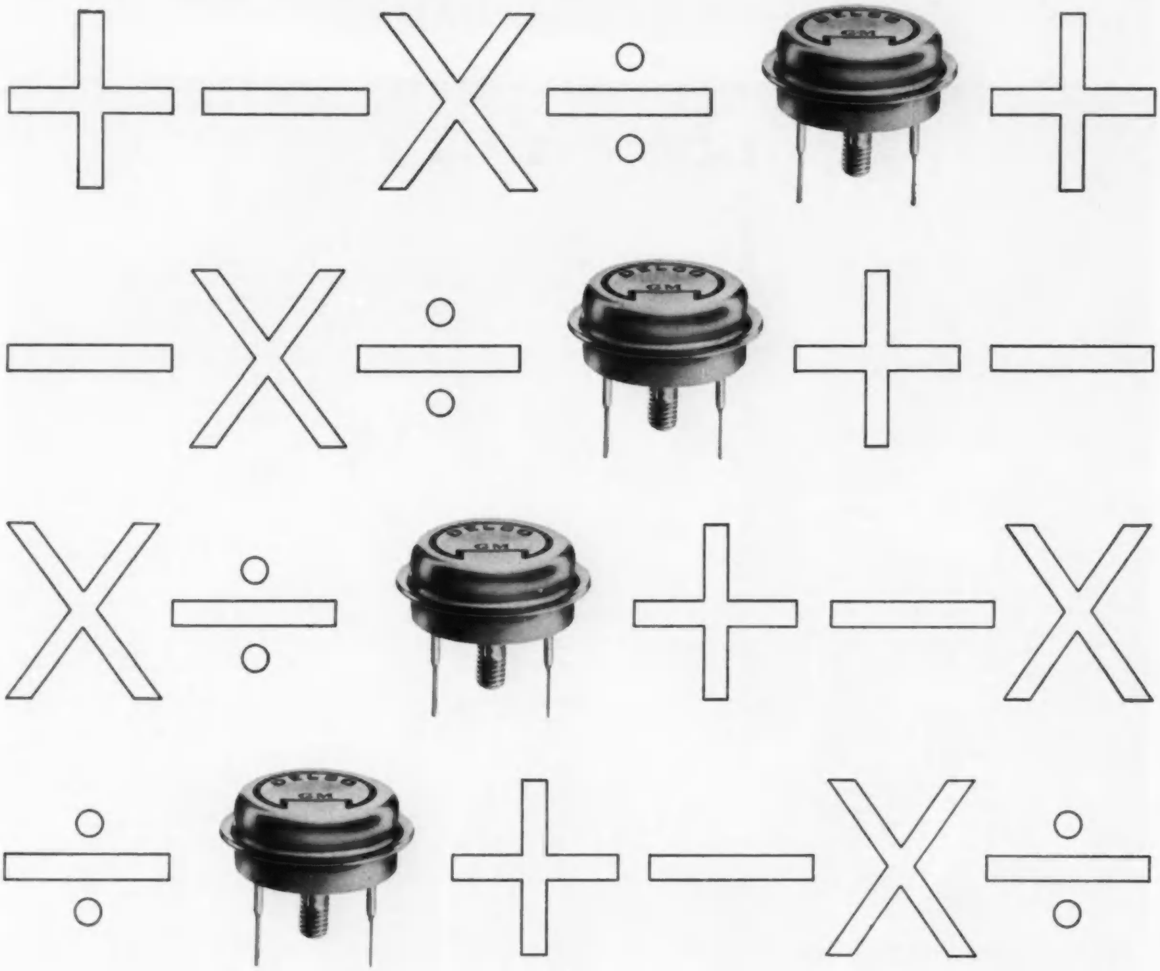

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With the right woven pile from Schlegel

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The answer is yours. You select the glass run channel and specify Schlegel woven pile liner. We furnish the channel manufacturer with pile fabric of the correct specifications.

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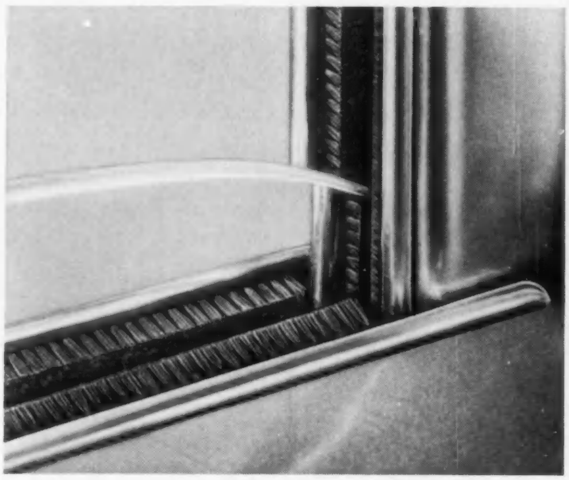
To you (and your car-buyer), Schlegel woven pile liner means easier window movement, rattle-free windows and better sealing qualities. It hugs the glass surface evenly, flexing against wavy surfaces to hold a constant seal.

If that sounds good enough to make you want the best, be sure your next glass run channel utilizes Schlegel woven pile liner. You'll be in good company. Automotive engineers have been specifying Schlegel pile liner since glass windows were first used in cars.



Glass moves friction-free, wet or dry, in this glass run channel with Schlegel woven pile

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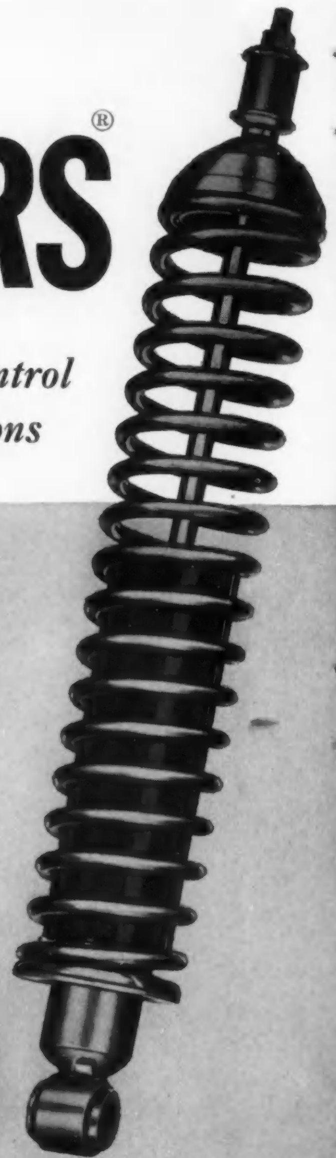

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- ✓ **Prevent "tail drag", side sway, and "bottoming" on axles.**
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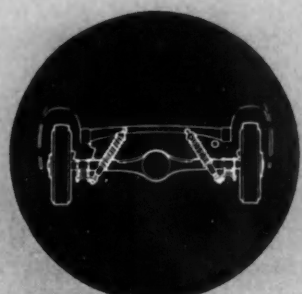
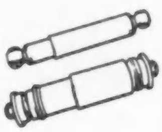
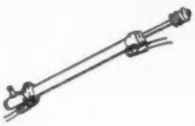


TYPICAL INSTALLATION: Monroe Load-Levelers are installed in exactly the same position and on the same mountings as the rear shock absorbers. They automatically compensate for all road and load conditions, provide maximum stability.



MONRO-MATIC SHOCK ABSORBERS—Standard on more makes of cars than any other brand.



DIRECT ACTION POWER STEERING—The only truly direct-action Power Steering units available.

MONROE SWAY BARS—Specified as standard equipment on 15 makes of passenger cars.

E-Z RIDE SEATS—Standard on more tractors than all other seats of this kind combined.

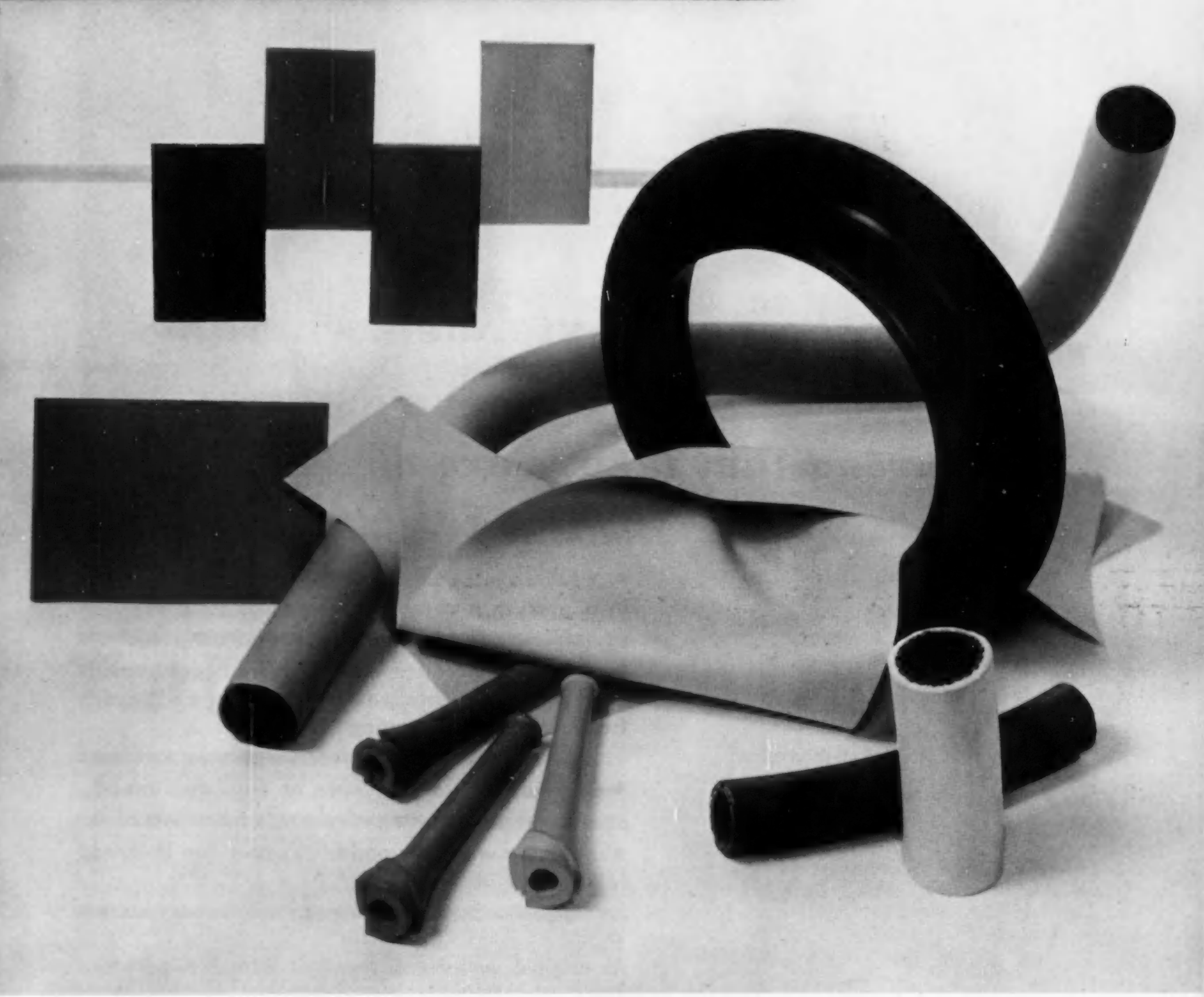
MONROE AUTO EQUIPMENT COMPANY, Monroe, Michigan

In Canada: Monroe-Acme, Ltd., Toronto • *In Mexico:* Mex-Par, Box 28154, Mexico City

MONROE *World's largest maker of ride control products including MONRO-MATIC Shock Absorbers*

Naugatuck PARACRIL OZO

THE OIL-RESISTANT, OZONE-RESISTANT NITRILE RUBBER



...tough, oil-proof, weather-proof and **colorful, too!**

The samples above should begin to give you some idea of the endless color possibilities in ozone-resistant rubber products made of new PARACRIL® OZO. Now you can give your product color that *sells*... color that identifies for coding wire and cable jacketing... color that blends or *contrasts*... color that works in a hundred ways. And you can give your product other superior properties, too.

Along with color, new weather-resistant PARACRIL OZO gives you a combination of high abrasion resistance, oil resistance, flex life and other valuable rubber properties far surpassing conventional weather-resistant rubbers.

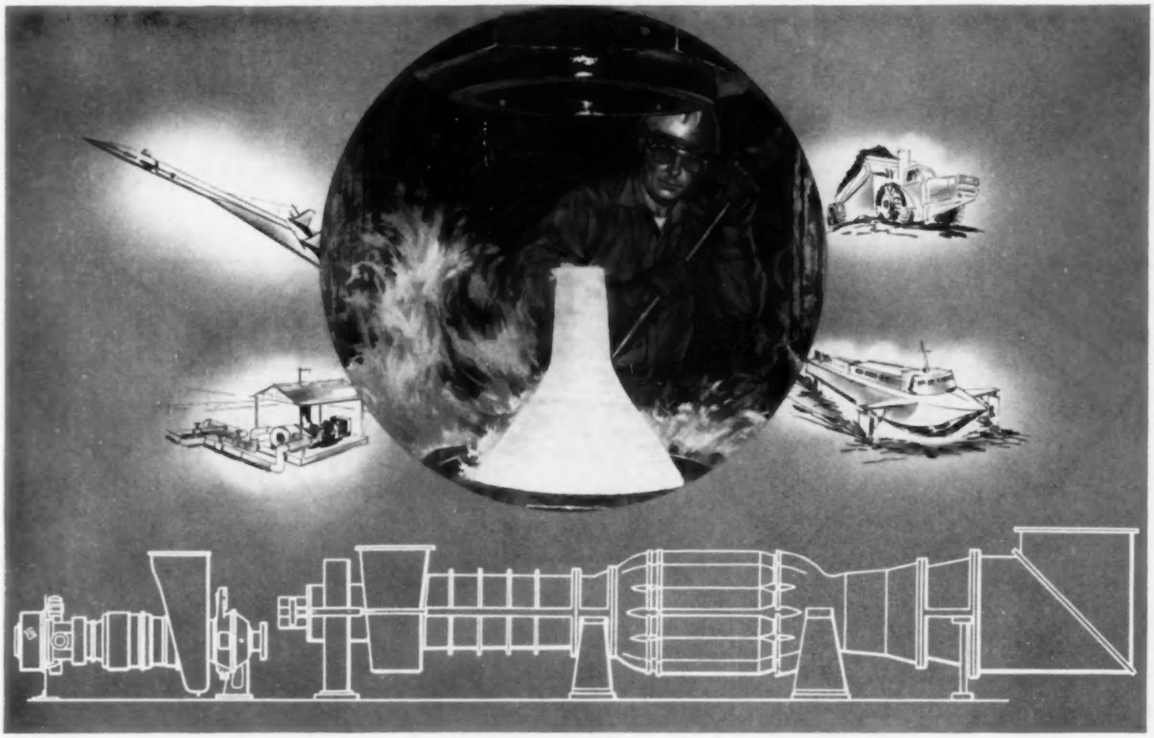
Cast a new eye on the rubber product you make or buy. See the difference color makes. See your Naugatuck Chemical Representative or write the address below for full information on PARACRIL OZO and the advantages it offers.

Naugatuck Chemical

Division of United States Rubber Company

Dept. A Elm Street
Naugatuck, Connecticut

Rubber Chemicals · Synthetic Rubber · Plastics · Agricultural Chemicals · Reclaimed Rubber · Latices · CANADA: Naugatuck Chemicals Division, Dominion Rubber Co., Ltd., Elmira, Ontario · CABLE: Rubexport, N.Y.



Turbine Forgings Unlimited

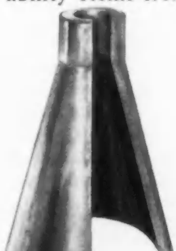
Few prime power sources depend so completely on part integrity for reliable performance as the gas turbine. Its extremes of temperature, rotating speed and imposed stress demand a level of metallurgical soundness available only in closed impression die forgings.

This is as true of workaday turbines—serving in the growing list of stationary, propulsion and auxiliary power applications—as for the most critical military designs. In each, dependability stems from component stamina.

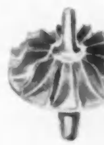
No other process approaches forging for optimum development of required properties, refinement in structure and precise control of flow characteristics. None combines high ultimate strength with comparable ductility to combat severe and sustained shock load.

Experienced leader in Automotive, Aircraft, Missile, Nuclear and Turbine fields, Wyman-Gordon is well prepared to meet your complete forging requirements. For one turbine forging—or thousands—contact Product Manager, Turbine Applications.

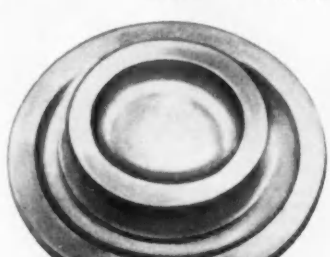
EST. 1883



Length 22"; weight, 190 lb.; material, nickel-base, high-temperature alloy (Cutaway shows uniform wall)



Diameter, 10"; weight, 45 lb.; material, Inconel X



Diameter, 29"; weight, 1000 lb.; material, Astroloy

Length, 18"; weight, 10 lb.; material, ironbase, high temperature alloy

Length, 22"; weight, 45 lb.; material, high-strength, nickel-base alloy

WYMAN - GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS — WORCESTER MASSACHUSETTS — DETROIT MICHIGAN

GRAFTON MASSACHUSETTS — LOS ANGELES CALIFORNIA — PALO ALTO CALIFORNIA — FORT WORTH TEXAS

Escon®

POLYPROPYLENE

GIVES YOU A BALANCED COMBINATION OF PROPERTIES...

When you take *all* the facts into consideration, you'll discover that Escon polypropylene gives you unusually high performance at low cost.

And, Enjay has complete commercial fabrication equipment to help solve your processing problems.

For technical assistance, write to Enjay at 15 W. 51st Street, New York 19, New York.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

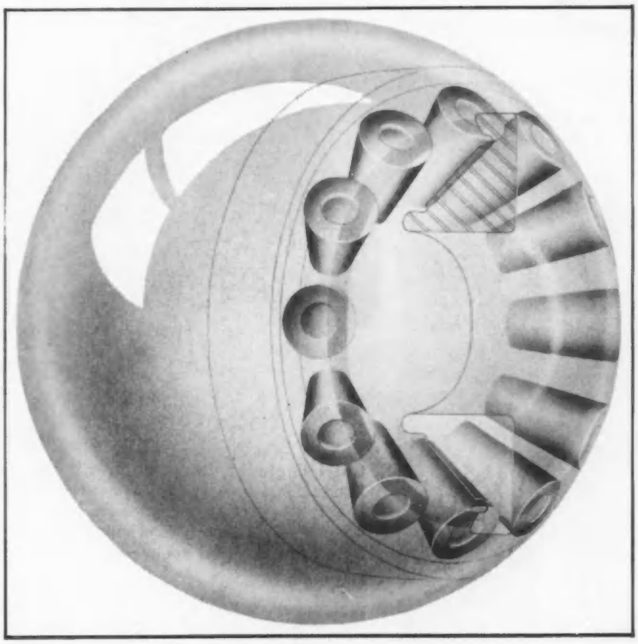
A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY
PLASTICS

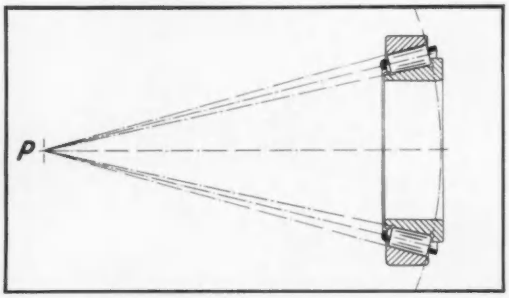
One in a series of technical reports by Bower

BEARING BRIEFINGS

SPHERICITY—ESSENTIAL TO MAXIMUM BEARING PERFORMANCE



When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.



True rolling of tapered bearing elements depends upon maintaining a true spherical radius during manufacture.

For a tapered roller bearing to achieve maximum performance, i.e., maximum life and capacity under load, it must have true sphericity — a condition of bearing geometry which permits true rolling of the tapered rollers in the raceway.

True rolling in tapered bearing elements is the result of maintaining a critical geometric relationship between the raceways and the contact surfaces of each roller. True rolling is essential to maximum performance. Without it, premature bearing failure is certain.

As engineers know, a tapered roller will describe a true circle when rolled on a plane surface. *It will always roll in this one path precisely, without sliding or skewing.* But to put true rolling to work in a bearing which can carry both heavy thrust and radial loads, it is essential that the rollers *and* the raceway have a true spherical radius, or sphericity. The drawing illustrates this condition.

If each roller in the bearing were to be extended in length, while retaining its taper, it would form a cone, terminating at point "P". All cones generated from all rollers would meet at point "P", which is also the center of the hypothetical sphere shown. The surface of the sphere would *touch all points on each roller's head!*

In effect, then, each roller's taper determines the radius of a hypothetical sphere whose surface, in turn, determines the correct contour for each roller head. Only when these conditions are satisfied in design, and when they are rigidly held during manufacture, will true rolling take place. In the manufacture of each Bower tapered roller bearing, sphericity is held within extremely narrow limits by means of special Bower-designed precision grinders. The consistent accuracy possible with these machines is one major reason why Bower roller bearings provide maximum performance under all speeds and loads up to the bearing's maximum rating.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

How to design sales power

HERE'S WHY ACME IRON WORKS

THE ENGINEER SAYS...

"It's easy to design equipment using International engines and transmissions. Accessory mountings are no problem, and International's technical experts are eager to help with special requirements."

—Marvin Quay, Chief Engineer, Acme Iron Works, San Antonio, Texas

▲ Chief Engineer Quay is an enthusiastic International booster, though not the first to specify IH power. For most of the company's 35 years in business, International engines have been standard equipment.

◀ Vice President and General Manager Bryant Ingram with new 10-ton pneumatic roller, powered by International UC-221 engine. The roller has five speeds forward and reverse, mounts five rear tires on oscillating axles.

Acme management is pleased with Engineer Quay's power choice. Mr. Ingram, General Manager of Acme, says, "We have installed thousands of International engines in our products and never had a complaint. They produce the right power, and have a long service life. Records show that they need fewer repairs. No matter where we may ship a roller, engine parts can be supplied quickly by International outlets in every part of the country."

An increasing number of designers and manufacturers are solving heavy-job power problems with International engines. When you specify IH power you simplify engine installation, service and repair. Should your design encounter problems, International engineers will help you work out a practical solution. Check your own requirements against the solid, sensible facts stated by engineers who prefer IH power. When all points are considered, the choice is International.

There are 35 models in the International line from 16.8 to 385 max. hp, stripped engines to complete power units. The wide range of sizes includes diesel, gasoline, LP gas and natural gas models, with features for extreme adaptability in every size. For further information call or write to International Harvester Co., Engine Sales Dept., Melrose Park, Ill.

into your products...

SPECIFIES INTERNATIONAL POWER

THE SALESMAN SAYS...

"People like International engines, and most of our prospects are already familiar with the extensive IH parts and service organization."

—E. M. Anderson, Vice President, Sales, Acme Iron Works, San Antonio, Texas

THE CUSTOMER SAYS...

"Our operation demands top performance and 100% availability. Experience with eight IH-powered Ingram Rollers has shown them to be most reliable. They give us steady operation, year after year, with only an annual inspection."

—Travis Jenkins, General Manager and V. P. C. H. Allison, Inc., San Antonio, Texas

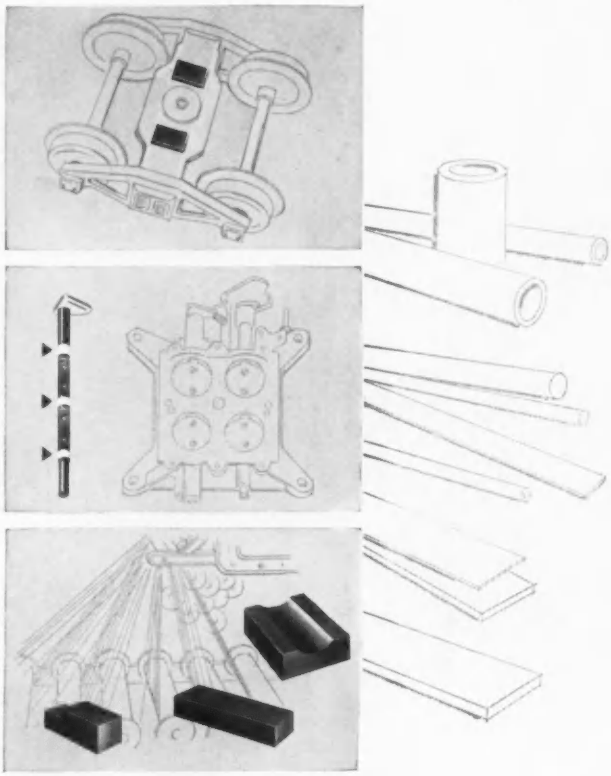
Acme salesmen sell their equipment by going over the product's features, point by point. When they come to the engine, they seldom have to say more than, "It's an International!" This, more than anything else, tells the prospect that the machine is quick-starting, economical to operate, and easy to service. It's the part you don't have to sell, because prospects are already familiar with International economy and dependability, as well as the world-wide parts and service organization. This pre-sold power package adds another plus feature to your sales story. Thousands of users report the outstanding performance of International engines. From crop sprayers in Florida to construction equipment in Alaska, the word is that IH-powered machines start faster, work better, last longer. Investigate International soon, and find out how easy it is to design Sales Power into your products.

INTERNATIONAL® ENGINES

International Harvester Co.,
180 North Michigan Ave., Chicago 1, Illinois
A COMPLETE POWER PACKAGE

NEW TEFLON BEARINGS

for Non-lubricated Service



Railroad truck bearings (top), carburetor bearings (center), and saddle bearings for textile machinery (bottom)—fabricated from top-quality Teflon* stock by Garlock—offer performance unmatched by any other material.

Now—new bearings of Teflon eliminate lubrication . . . resist extreme temperatures and reactive chemicals . . . drastically reduce downtime.

No finer combination of properties. Bearings of Teflon offer a lower coefficient of friction than any other solid material; they have exceptional thermal stability and are suitable for continuous service to +500°F; they are completely resistant to nearly all chemicals and solvents; they are tough, abrasion-resistant, have no moisture absorption.

Applied where safety and reliability are essential. Teflon is used as journal and thrust bearings, and on other sliding surfaces where lubricated bearings are undesirable, or incapable of operation in extreme temperatures or corrosive conditions, or where there is a possibility of lubricant failure. Teflon bearings afford unexcelled performance where slip-stick motion must be minimized . . . on reciprocating and oscillating systems where the lowest possible static friction must be attained . . . where space and weight savings are essential.

Easily fabricated from high-quality Garlock stock shapes. Teflon bearings can be simply and economically made from standard Garlock tape, bar and rod stock available through local Garlock distributor outlets. Or, if you wish, Garlock will work to your exact specifications in furnishing bearings of all tolerances and size. Whatever the case, the key to best bearing performance is through the use of Teflon stock shapes by Garlock. With years of experience in research and processing of plastics, Garlock is able to recommend and furnish *exactly* what you need, when you need it, and at the lowest possible cost.

Find out more about Teflon bearings. Consult your local Garlock representative at the nearest of the 26 Garlock sales offices and warehouses throughout the U.S. and Canada.

Or, write for Plastics Catalog AD-177, Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

*DuPont Trademark

working with

Du Pont
ZYTEL® NYLON
RESINS

one of Du Pont's versatile engineering materials

Why tubing of ZYTEL® offers unique property and cost advantages

The combination of properties offered by Du Pont ZYTEL nylon resins has led to an ever-increasing use of these engineering materials in the form of molded automotive parts. The properties which make molded components of ZYTEL so useful are also characteristic of tubing of ZYTEL. No other tubing material can provide the advantages offered by ZYTEL.

Low specific gravity (from 1.07 to 1.14) makes possible a significant weight saving over metallic tubing—particularly important in the light of today's automotive design trends.

Unlike other thermoplastics, ZYTEL couples with this low weight other necessary design properties, such as outstanding mechanical strength, flexibility, chemical resistance, fatigue endurance and resistance to high and low temperatures.

Successful commercial applications based on these properties include automatic lubricator tubing, air suspension tubing, vacuum spark lines, control and rotary cable liners.

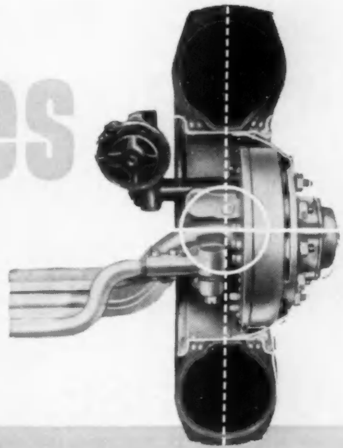
• • •

The booklet shown above will furnish you with detailed information on these various properties of ZYTEL in tubing applications, additional design information, and a discussion of suitable fittings, to help you evaluate tubing of ZYTEL for *your* application. For your copy, mail coupon on facing page.

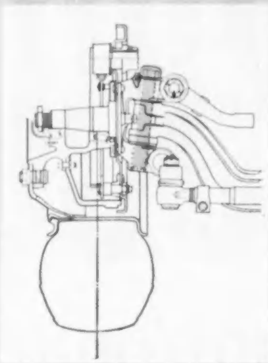
'Way out front in steering ease...

"CENTER POINT"

steer front axles

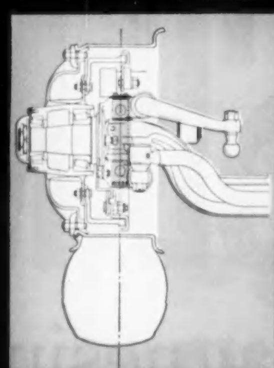


Rockwell-Standard® Center-Point steer for heavy-duty vehicles gives you 3 advantages • Easy steering with less weight and cost than power assist • Safer, better vehicle control with less driver fatigue • Reduced maintenance costs and less downtime because tires and steering parts last longer.



THE ORDINARY WAY

Inclined kingpin design necessitates lifting the front axle load when wheels are turned. Because linkage is a greater distance from center-line of tire, and is not perpendicular to ground—it is subject to many forces not present in the Center Point design.



THE CENTER POINT WAY

Steers the truck without lifting the load. Vertical kingpin is perpendicular to the ground—eliminating the need to lift the load. Knuckle pin bushings and linkage parts last longer because of the load reduction . . . steering is easier.

EXTRA! THESE TIME-PROVED ROCKWELL-STANDARD FEATURES

Delrin Knuckle Pin Bushings—cannot rust or corrode.

Forged Steering and Tie Rod Arms—extra strength and rigidity.

Balanced "I" Beam Center—equalized "I" design gives greater resistance to both lateral and vertical stress.

Air or Hydraulic Brakes—whatever is best for your operation.

True Sphere Ball Studs—induction hardened for longer wear.

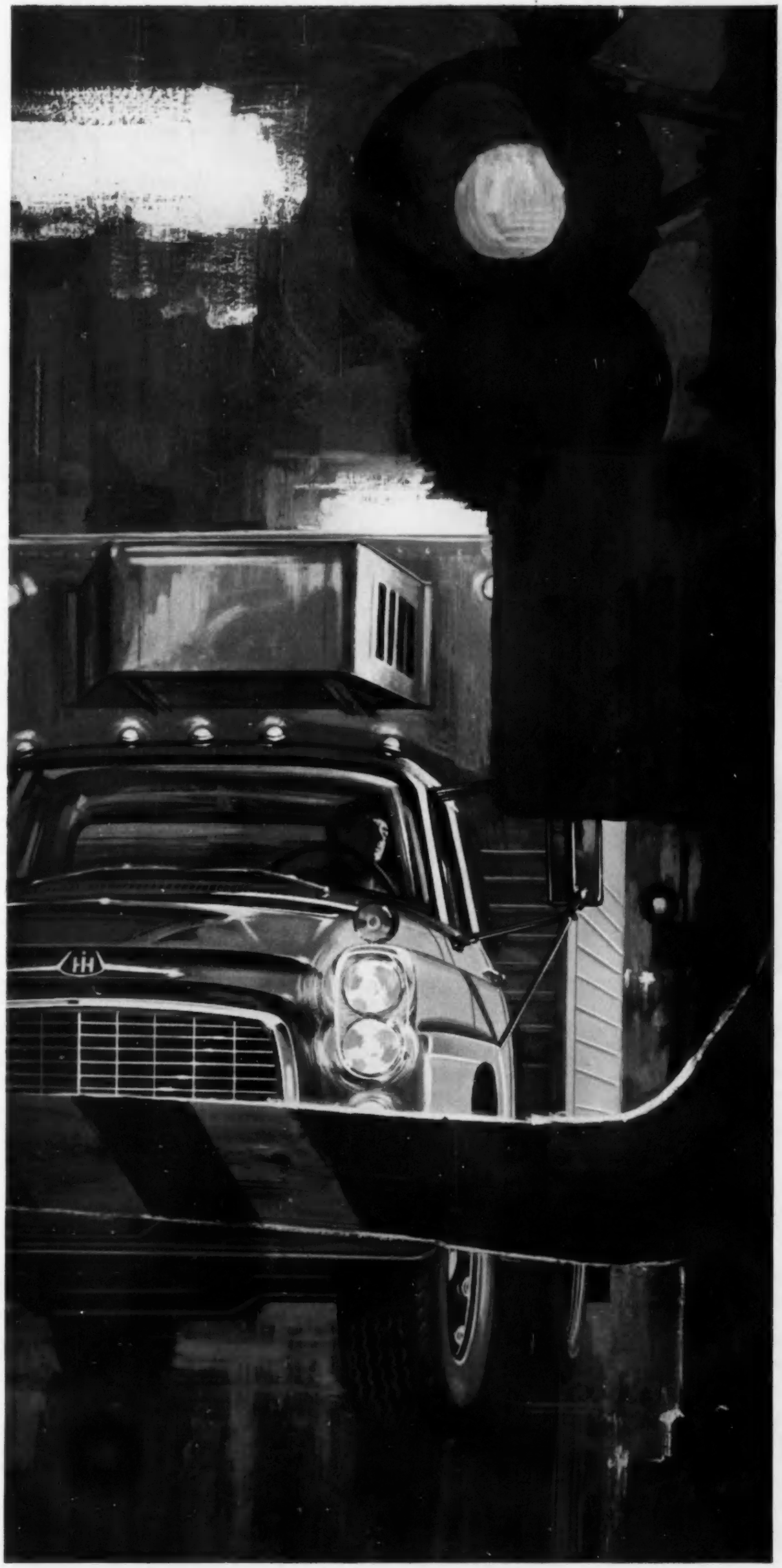
Simplified Maintenance—simplified design cuts maintenance cost, speeds lubrication.

Forged Knuckles and Spindles—enclosed, to keep lubrication in, dirt out.

Another Product of... **ROCKWELL-STANDARD** CORPORATION

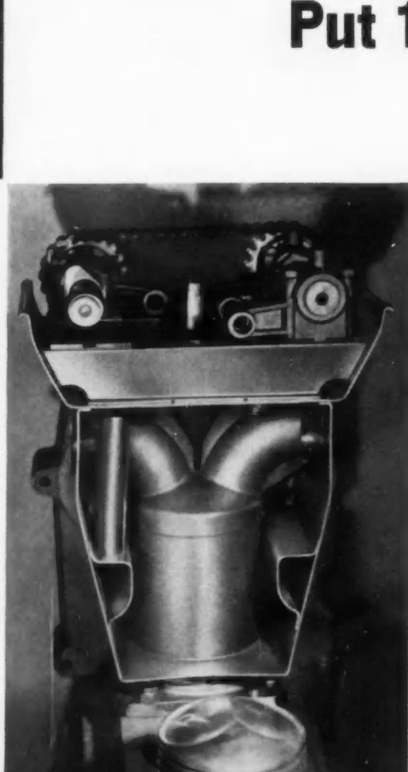
ROCKWELL R STANDARD ®

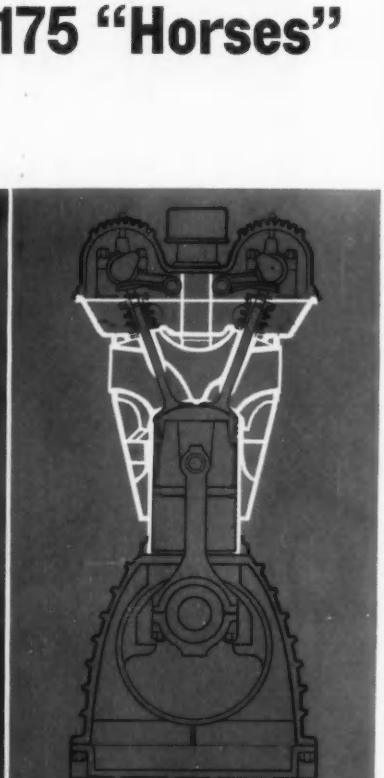
Transmission and Axle Division, Detroit 32, Michigan



How Armco Stainless Put 175 "Horses"

Use this label to tell customers where you use durable, modern stainless steel.



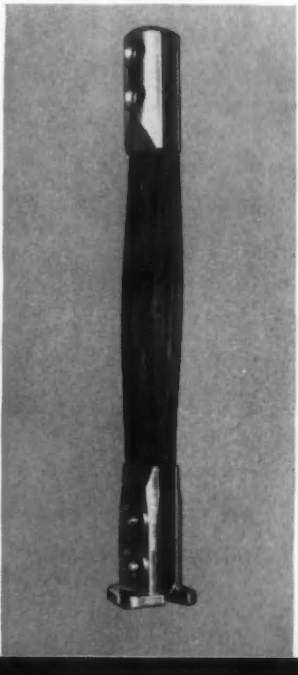


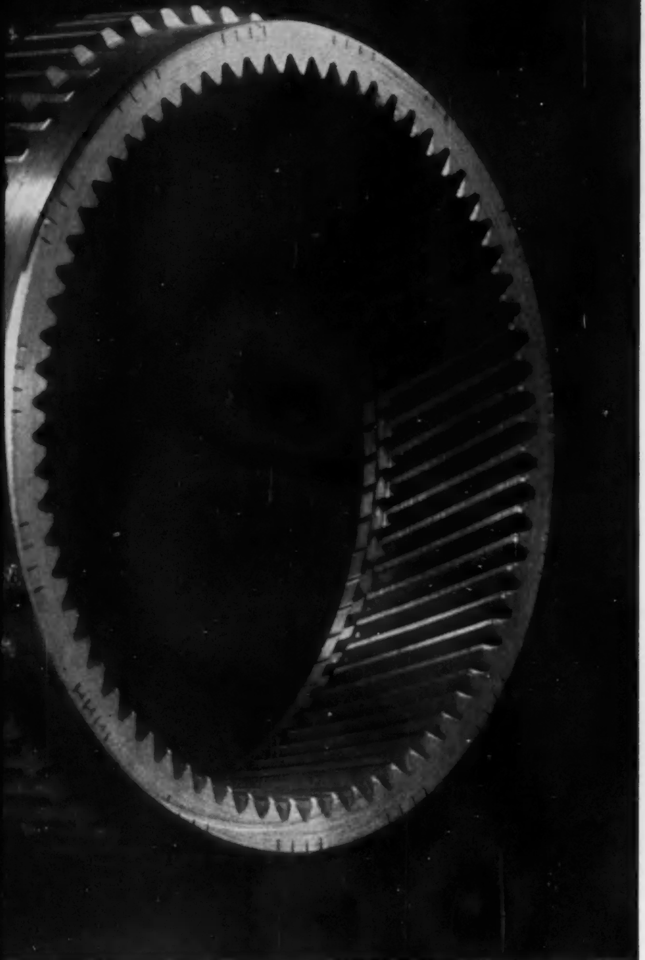
Cylinder block sections formed from Type 302 stainless are joined by spot-welding and copper brazing. Coolant galleries, cylinders and cylinder heads, valve pan, intake and exhaust ports are made from stainless steel.

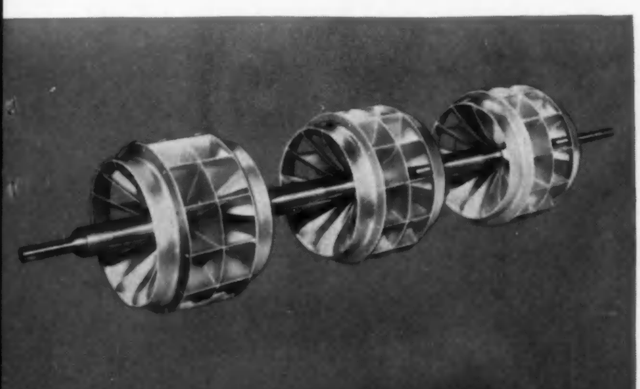
3-DIMENSIONAL METALLURGICAL TEAMS:

Republic's mill, field, and laboratory metallurgists and machining experts help you select and apply the metal best suited to requirements. Mail coupon for details on this confidential, obligation-free service.

KAMAN AIRCRAFT CORPORATION, Bloomfield, Connecticut, uses Republic Titanium in the rotor system of their HU2K "SEASPRITE" Helicopter. 1½" x 18" titanium (type RS140) strips are assembled in bundles of 88 and machined into retention straps capable of working through a torsion angle of ±13°. Each strap provides a minimum tensile strength of 155,000 psi.








HOB TWO
FOR THE PRICE
OF ONE
By switching to a lead-treated steel, Thor Power Tool Company cut the cost of these idler gears in half. Aristoloy 4620 (leaded*) provided high strength with excellent wear and shock resistance qualities. On gear cutting operations, machinability jumped from 35% to 66% (of B 1112). And there was a marked improvement in surface finish.
If you would like to know more about the production economies of lead-treated steels possible on hobbing, broaching, milling, and particularly automatic machining operations, write today for LEADED STEELS CATALOG. Or call your nearest Copperweld representative.
*Inland Ledloy License
ARISTOLOY STEELS
DIVISION OF
COPPERWELD
STEEL COMPANY
ARISTOLOY STEEL DIVISION
Steel
4035 Mahoning Ave., Warren, Ohio · EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.

When Should Alloy Steels Be Ordered to Hardenability?

What is hardenability and how does it differ in carbon and alloy steels?

Hardenability can be defined as the capacity of steel to develop a desired degree of hardness, usually measured in depth. It is produced by special heating and cooling. Carbon steel, except in small sections, will normally harden to a depth slightly below its surface, while alloy steel can, under certain conditions, harden uniformly through its entire cross-section.

Surface hardness obtainable after quenching is largely a function of the carbon content of the steel. Depth hardness, on the other hand, is the result of alloying elements and grain size, in addition to the carbon present in the steel.

In general, where hardenability is the prime consideration, it is not too important which alloy steel is used, just so long as there is sufficient carbon present to give the prescribed hardness, and there are enough alloying elements to quench out the section. It is not considered good practice to alloy a small section excessively, since excessive use of alloying elements adds little to the properties and can, in some instances, induce susceptibility to quenching cracks.

There are, of course, numerous cases where factors other than hardenability must be considered; such factors as low-temperature impact, heavy shock, creep-resistance, and the ability to resist temper brittleness. Through-hardening, therefore, is not always desirable. For example, shallow hardening is often necessary in shock applications, because a moderately soft core is essential.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

Steel

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

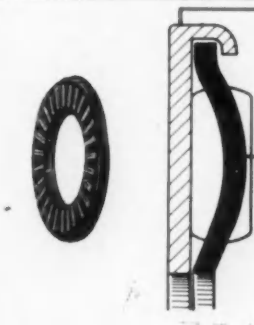
A product of

NADELLA engineering skill

The new

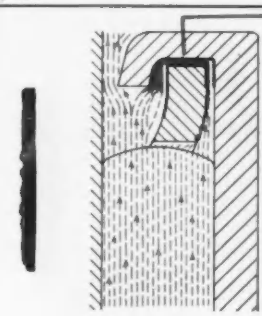
Needle Roller Thrust Bearing

Takes no more space than a washer



Incorporated race
Positive needle retention:
— **easy mounting**

Rugged one-piece retainer :
— **Robust construction**
— **Precision quality**



Accurate, well-lubricated surfaces give positive retainer centring :

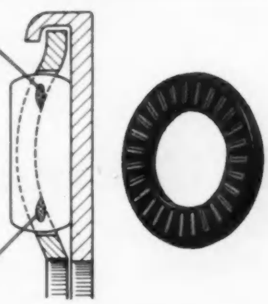
— **No wear of shafts and housings**
(even where not hardened)

— **No overheating**

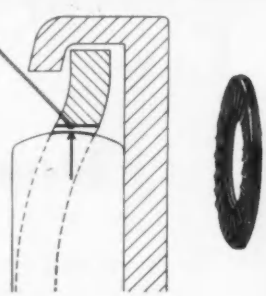
Needles precisely held on their pitch-line and by their tips only :

— **No stray load components**

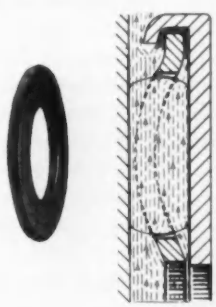
— **Minimum friction, wear and heating**



Pivot-like centre point contact only at needle ends :
— **Minimum friction**



Larger number of needle rollers
— **Maximum load capacity**
— **Maximum resistance to load surges**

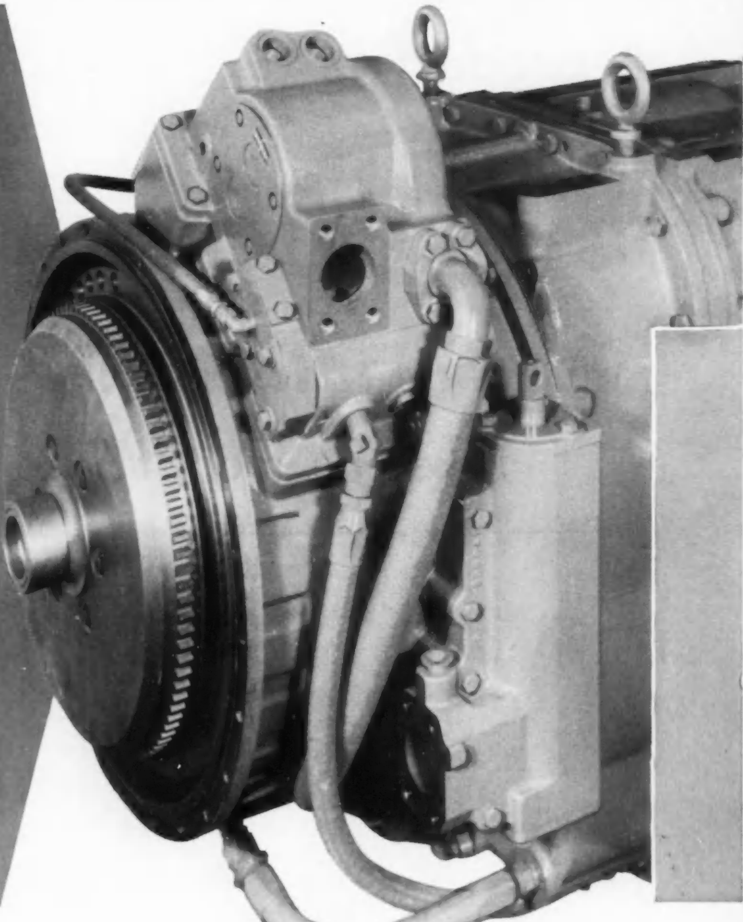


Generous lubricant feed to contact faces :
Lubricant cannot wipe off, no dry running friction :
— **Suitable for grease lubrication**
— **High speeds without heating or wear**

S.A. des Roulements à Aiguilles NADELLA **133-137, Bd National ; RUEIL-MALMAISON (S.-&-O.) FRANCE**
Phone : 967-10-15 (+) **Cable : Guillarou - Paris**

NEW

Torque Converter and Constant-Mesh Transmission



Designed SPECIFICALLY for

TWIN DISC, which introduced America's first torque converter in 1936, has a wealth of experience in designing converters for such applications as construction machines, oil rigs and logging equipment. But in designing the 18" converter for a new power-shift transmission package for heavy-duty vehicles, Twin Disc engineers had to solve a number of special problems.

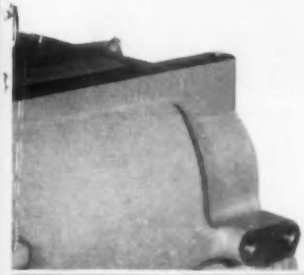
There are long stretches when a truck does not require torque multiplication. For peak efficiency during these periods, Twin Disc has included a freewheeled stator in its new single-stage converter. When the need for torque multiplication falls off, the speed of the pump wheel approaches that of the turbine. This reduces the reaction force on the stator to the point where it freewheels. The converter becomes in effect a fluid coupling, and the result is higher efficiency.

This efficiency can be stepped up still further under 1:1 ratio conditions by means of a front-end lock-up clutch on the converter. Engagement of this clutch provides direct drive performance.

Also featured in this new converter is a hydraulic retarder. Loads on truck service brakes keep going up, yet their capacity is limited by the available brake space at the wheels. The hydraulic retarder absorbs a high percentage of the vehicle's kinetic energy, dissipating it in heat. This saves wear on the brakes and permits safe, controlled descents at higher speeds.

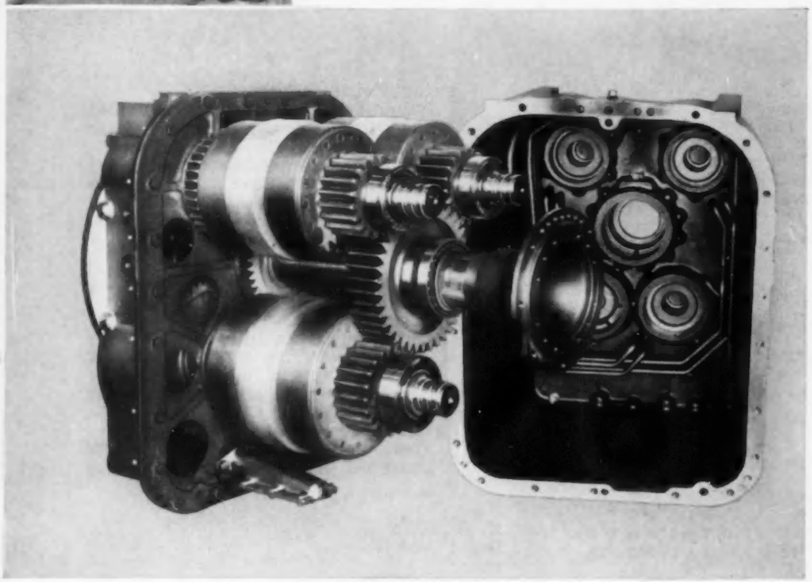
The torque converter can be supplied as a separate unit or as part of a converter-transmission package with the new Twin Disc TA-51-2000 Power-Shift Transmission. This transmission permits gear-shifting on up-hill hauls without power interruption or loss of momentum.

The TA-51-2000 is a straight-through countershaft unit with constant-mesh gearing. Shifting in all ranges at full engine power is

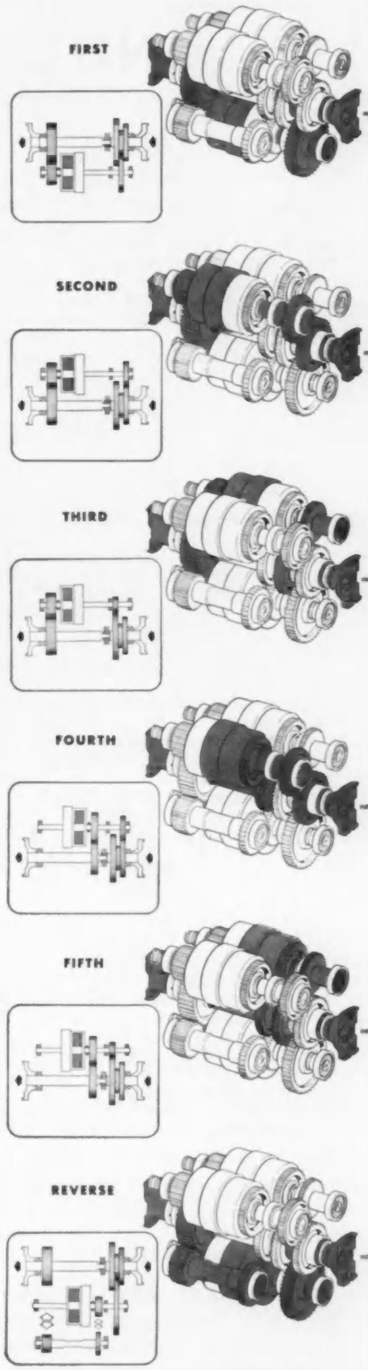


Three models available in the TA-51-2000 Series

Model No.	Max. HP	Max. Torque (lb.-ft.)	Max. Speed (rpm)	Ratio Spread
TA-51-2001	420	1050	2500	5.93:1
TA-51-2002	420	1050	2200	6.80:1
TA-51-2003	420	1050	2800	5.45:1



Transmission Power Flow



Vehicles... by TWIN DISC

through multiple-disc, oil-cooled, hydraulically actuated clutches. There are five forward ratios and one reverse. A modified version, called the TA-33-1600, has three forward and three reverse speeds. Four different drop boxes are available to meet special drive requirements.

The converter is used only in the first two ranges to get the load moving or to meet low-speed tractive-effort demands. The second ratio has two selector positions, one for drive through the converter and the other for use when the converter is locked up. Lock-up range thus extends from the second through the fifth ratio. Where desirable, a manual over-ride can be provided to permit converter drive in all ranges.

A noteworthy feature of these converter-transmission packages is interchangeability of parts. Gearing can be easily changed to match engine modifications, thereby simplifying inventories and service.

Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division, Rockford, Illinois.

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